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Technical Lesson 38

PRINCIPLES AND USE OF TEST EQUIPMENT FOR SERVICING RADIO RECEIVERS

It requires only a little looking around to see what a marked difference there is between the design and construction of radio receiving sets manufactured at the present time and those turned out by the radio industry in previous years. You might wonder what has brought about the numerous changes in radio sets in such a comparatively short time. One of the principal reasons is that modern productive methods have been applied in building radios—methods which follow closely along lines similar to those employed in many big industries where products are manufactured in large quantities and are subjected to rigid inspections and performance tests before they leave the factory. Other reasons which are responsible for the new models are the rapid development of screen-grid tubes and the radio circuits in which they function and, also, the almost universal adoption of a-c electrically operated sets that obtain their power from a socket or wall outlet in the house lighting system.

Considered both from the electrical and mechanical standpoints our present type radio sets are superior to the older models in practically every respect but along with this advancement in set design and all around improvement in set performance there comes a big problem. That is, the problem of testing and servicing these receivers. In answer to the general requirements for making rapid and accurate tests on tubes and receivers there has been developed a few comparatively simple test instruments which are within the command of radio service men.

Throughout the entire radio field there are, of course, a great variety of instruments in use for different purposes as a study of other lessons in our radio course will reveal. This lesson will be devoted to a study of instruments which have been found to be most useful in practical radio servicing. In the list immediately following we have included the names of those instruments which undoubtedly offer the greatest aid to the systematic worker in testing tubes, making adjustments and locating faults and troubles in receivers of practically every description. These instruments are; namely, a radio set tester which is also called a set analyzer; a tube tester or tube checker; a continuity tester and ohmmeter and volt-ohmmeter; an r-f and modulated oscillator; a grid dip meter and an output meter. A vacuum tube voltmeter is also included because it is frequently used in servicing and testing work this meter affords an excellent means for making comparative measurements.

In reading over the names of the instruments just mentioned you can realize that a lesson of this kind on the subject of up-to-date routine servicing of radio sets and testing tubes must necessarily deal mainly with the use of meters. The importance of a thorough knowledge of meters and their use and the ability to interpret the meaning of any indication read on a meter scale

cannot be overestimated in this work. In fact, one manufacturer believes that through lack of necessary electrical testing equipment a person is unable to intelligently record the condition of a radio set and there is no doubt but that he is right in his contention. His statement is just another way of saying that when suitable test instruments are employed and properly handled it eliminates all guess work from radio servicing. And speaking of guess work recalls to mind conditions which existed a few years back when the majority of receiving sets were battery operated, and the parts and accessories were assembled together in a maze of open wiring, and how radio troubles were oftentimes located in a more or less haphazard manner. A good guess or two by an experienced radio man as to the probable cause of trouble in some of the one to three-tube sets that he was called upon to service and he would in many cases hit right on the fault.

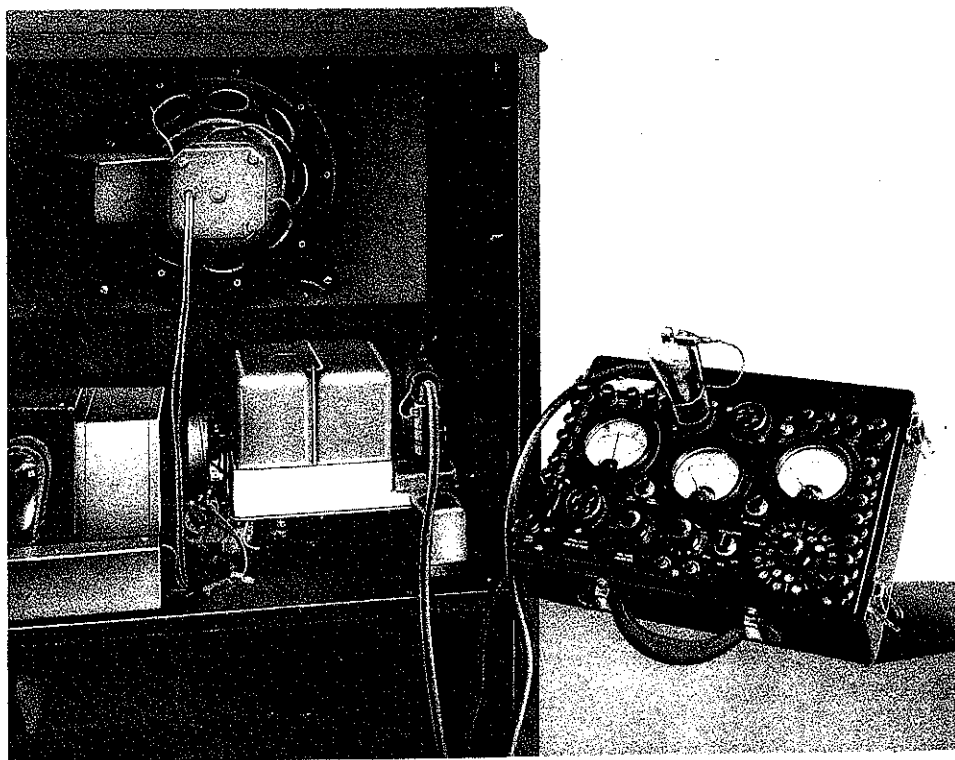


Figure 1

Nowadays, however, conditions are entirely changed in the service field of the radio industry. The highest character of service must be rendered to owners of radio sets because of the keen competition in this line and this means that the most efficient testing methods must be put into practice. In other words, when working on a set that is operating unsatisfactorily or perhaps not operating at all a serviceman aims to get at the real source of the difficulty in the shortest possible time and to do this on modern radio sets requires that a regular system of tests be made according to standard practices. We will outline these for you in a subsequent section. Of course you will soon learn that systematic electrical testing of troublesome receiving sets of any type, whether they be new or old models, is a distinct advantage over tests attempted by any of the so-called hit and miss methods.

Most everyone knows that when a receiver of recent manufacture is installed in its cabinet or console only a very small portion of the wiring and component parts of the receiver proper and power supply units and loudspeaker are readily accessible. This is accounted for, as the photograph in Figure 1 clearly shows, by the mechanical layout of the recent models which are built on the unit plan, employing chassis form of construction, and, also, because of the generous use of metal covers and containers and shielding cans which enclose the parts. It is quite obvious that in servicing sets which are assembled according to this unit plan that certain preliminary electrical tests are very necessary to expedite the work.

The illustration in Figure 1 is a typical example of modern test methods being employed to check the circuits of a receiver. It shows a set tester being used to take voltage and current readings at the 1st r-f socket of an electrically operated screen-grid receiver. You can see that the screen-grid tube has been removed from its socket in the receiver and is inserted in the UY socket on the set tester panel and the tube has been replaced with a tester plug; hence, the plug is in the 1st r-f socket previously occupied by the tube. To complete the connections for such a test the control grid lead coming from the r-f coil is clipped to a small terminal located on the side of the plug while another connection, which is part of this same circuit, is made at the tester by means of a short lead. As shown in the photograph one end of this short lead is clipped to the metal cap control grid terminal at the top of the tube and the other end is fastened to a binding post on the panel. It should be mentioned that in using this particular set tester the control grid terminal of either a screen-grid or pentode tube would be connected to this binding post by means of the short wire.

In the cable which joins the tester plug to the set tester are several wires which you cannot see. These wires at the plug end connect to prongs in the plug base which are similarly arranged to the prongs found on a tube base, whereas, the opposite ends of these wires which terminate at the set tester lead into various meter and socket circuits through the switching arrangement. Thus, when the plug is in the position shown in Figure 1, the wires in the cable serve to carry each circuit terminating at the contacts of the tube socket in the receiver over to corresponding contacts of the set tester socket where the meters are located. This is known as a tube-socket analysis.

This method of extending certain receiver circuits over to the set tester provides an easy means for getting at the various voltages and currents since all you need to do, after setting up the tester for operation, is to manipulate the proper buttons, switches and dials provided on the tester panel for connecting the a-c and d-c meters into the tube circuits and then observe the readings. Our diagrams of various tester circuits which you will come to a little later in this lesson explain exactly how the meters and circuits are arranged and controlled.

A thing to keep in mind in this work is that all receivers are fundamentally alike insofar that certain circuits are directly supplied with potentials from the power supply system and such circuits usually terminate in one way or another at the contacts of the different tube sockets, whereas, certain other circuits may or may not connect directly to the power supply system or to any of the receiver sockets.

To check circuits in the latter class would require the use of another test instrument, the continuity tester, which is described under that subject. Two examples of circuits found in many receivers for which a socket-analysis test, such as the one illustrated in Figure 1 would not be applicable, are the input, or antenna circuit and the output, or loudspeaker circuit. In modern set design the loudspeaker windings are connected to the power circuits only indirectly through a transformer or a condenser and choke coil combination, and the antenna system is in many cases inductively coupled to the input, or grid circuit comprising the 1st r-f stage of amplification.

However, in the case of circuits which are included in the class previously mentioned first, or circuits associated directly with the power system and the vacuum tubes, they are to be thought of as a number of arteries leading into and out of the tubes by way of the tube sockets. For instance, each plate, grid, filament and cathode circuit centers at some tube socket contact and, therefore, when these circuits are supplied with potentials the potentials will in turn be applied to corresponding electrodes in the tube itself, that is, to the plate, grid and so on. Of course, the circuits and tube must be in good condition and the tube properly seated in its socket before the potentials will be effectively impressed on the electrodes.

Thus, it is easy to understand that by placing a tester plug in one of the sockets of a receiver and the tube in the set tester socket, as shown in Figure 1, the voltages and currents can be quickly and accurately checked to cover one section of the receiver. By making tests in this manner at all of the tube sockets in succession you obtain readings on the meters which give you a good part of the information needed for determining the operating characteristics of the entire receiver.

Remember, that with power on an electric set every socket should be supplied with a tube, hence, when a series of readings are to be taken only one tube should be removed at a time, never more, the exception being in the case of the socket at which the test is made and, as we have already explained, this socket must hold the tester plug and the tube which was removed should be placed in the set tester socket. If an electric set were operated with one or more tubes missing from their sockets it would place some additional load on the remaining tubes. This would be noticeable in particular with regard to the filament and heater voltages. These voltages, which are furnished by secondary windings of the power transformer, would go up above normal values and, hence, excessive current would pass through the filament and heater wires of the tubes affected and if allowed to persist this might cause permanent damage to them. Moreover, the readings obtained under such circumstances would not indicate true circuit conditions; if possible, keep all circuits intact.

Electrical tests which involve the use of a set tester are usually made with the receiver placed in as near normal operating condition as possible, that is, with the volume control and tuning dial adjusted in the usual way to bring in a signal. Or, it may be preferable in some cases to first take a series of readings with the volume control set at its maximum volume position, which gives maximum distribution of voltages and currents through various circuits in the receiver, and then take a second series of readings with the volume control in its normal working position. A comparison of the two sets of readings will show whether any radical difference exists between them and if any is found it may prove helpful in checking up the possible source of trouble.

If a set is power operated, then before you turn on the operating switch it is always best to make sure that the set is connected into an electric lighting circuit of the proper voltage, a-c or d-c, and if the power source is a-c its frequency must be correct for the characteristics of the power transformer used in the set. The frequency generated in most of the power stations throughout the country is 50-60 cycles and in only a few localities will you find 25 cycles or other miscellaneous frequencies used.

If tests were to be run on a battery operated set you would make sure that the batteries were properly connected and that the voltage of each battery was sufficient for normal working conditions and, also, if the set were provided with a rheostat you would ascertain whether the rheostat needed adjusting to supply the correct filament voltage to the tubes. Electrical testing through tube-socket analysis, that is, measuring voltages and currents at tube sockets as shown in Figure 1, is by no means limited to a-c receiving sets. It can be applied to all types of receivers which includes a-c and d-c electrically operated sets, battery operated sets, and radios which use socket-power devices, such as "A" "B" and "C" eliminators, but were originally designed for battery operation.

Before getting into the numerous details which are involved in radio set testing we will cover some of the more general points on service equipment and routine testing. Therefore, let us again refer to Figure 1 and use this illustration to explain how certain wiring and parts in the receiver shown can be quickly analyzed by the indications on the set tester meters. There are three meters on the set tester which read as follows:

(1) The a-c voltmeter on the left is indicating the a-c voltage supplied to the heater of the screen-grid tube. The voltage for this circuit is obtained from the heater winding of the power transformer which provides unrectified a-c, commonly called raw a-c.

(2) The d-c voltmeter in the center shows the d-c potential supplied to the tube's plate and when normal value is indicated it means that every circuit and part thereof that carries this d-c power is operating satisfactorily. This includes the resistor or resistors in the voltage divider system which furnish this particular voltage and, also, the filter and rectifier circuits.

(3) The d-c milliammeter on the right allows you to read the value of direct current passing through the plate circuit of this tube. The fact that a flow of current is indicated tells you that the plate circuit is continuous or unbroken throughout its entirety. This circuit takes in the vacuous space within the tube from cathode to plate, the primary coil of the first radio-frequency transformer, portions of the power supply system, the plate return or --B circuit which includes in this case a grid bias resistor and, also, other items that would affect the operation of this circuit, such as socket contacts, tube prongs, wiring and so on.

Since the meters on the set tester in Figure 1 are shown reading continuously it is well to mention that by different forms of mechanical construction in the dials, buttons or switches used to control tester circuits the meters can be kept in circuits under test as long as desired. This permits

more than one reading to be taken at the same time when the instrument is equipped with two or more meters. If buttons were used for this purpose it would only be necessary to turn them left or right after depressing them to lock them down in position.

Another thing we should mention concerns the arrangement of binding posts on the set tester panel. The binding posts connect to the various meters and, therefore, by attaching suitable test leads to certain related pairs of binding posts the different scale ranges of the instruments are made available for any external use. For instance, the meters could be used for taking voltage and current measurements directly on batteries, socket-power devices and for making continuity tests, or for any purpose, of course, within the limits of the meter scales in checking circuits which cannot be conveniently reached through the plug and tube-socket analysis. It should be noted that on certain tester panels you will find pin jacks supplied instead of binding posts for making connection to the meters when they are to be used independent of the tester circuit itself.

The small sketch in Figure 2 shows a receiver chassis which has been removed from its cabinet and is being subjected to a socket-analysis test with a set tester equipped with two meters. One meter is used for measuring a-c values and the other for d-c values. An instrument like this one can be designed to provide the same ranges of a-c and d-c voltage and current values as the three-meter tester shown in Figure 1. Multi-scale meters are used on set testers and other types of instruments so that each meter may be used for measuring wide ranges of voltage or current values, or both. The scales or ranges provided, of course, depends upon the practical application of the meter. From your previous study about meters you will recall that in order to calibrate a meter scale to a new range it is necessary to connect a resistor of specified value either in shunt or in series with the meter according to whether it is intended for use in measuring voltage or current in a circuit.

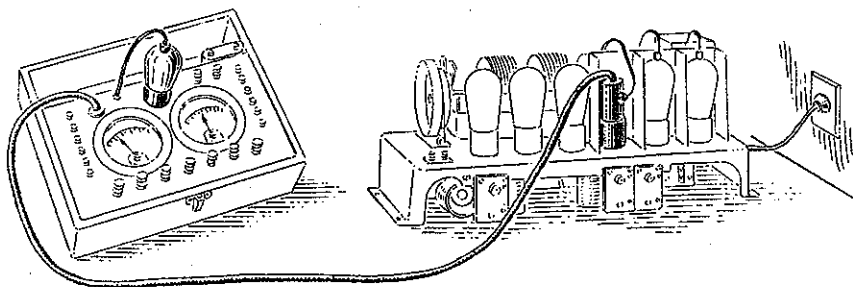


Figure 2

Let us again review these principles: In the case of current reading meters the resistor must be connected across the terminals of the meter or, as we say, in shunt with it in order to increase the range. The resistor may be located either within the meter instrument case or external to it and different sizes of resistors are selected to make the instrument read amperes or milliamperes as desired. The idea of the shunt or parallel connection is that two paths are furnished through which the main current can flow. One path is through the meter and the other through the shunt and the amount of current carried by each path will depend upon their comparative resistances, that is, the ratio between the shunt and meter resistances.

In the case of a voltmeter, however, a resistor must be connected in series to increase the meter's range and, therefore, the same amount of current will flow through both the meter and the resistor. A resistor used for this purpose is called a "multiplier". The reason for the series connection is as follows: When the e.m.f. of a circuit to be tested is applied to the terminals of the meter and its multiplier, which are in a series arrangement as already stated, we get a very much higher voltage drop across the resistor than across the meter. This is because the resistance of a multiplier is always far greater than the resistance of the winding in the meter, and, as you know, it will take more of the available voltage to force the same current through the higher resistance. The result is that only a very small value of e.m.f. remains to be impressed on the meter to make it function. So, with a suitable arrangement of switches and shunt and multiplier resistors we can make one meter provide many scales or readings. To illustrate the practical use of shunt resistors let us suppose, for example, that a certain milliammeter is already provided with two ranges, say 20 and 100 milliamperes, and that either range may be used by throwing a toggle switch, and, also, suppose that by the proper use of other shunt resistors and switches we have increased its range to 2 and 10 amperes. These four ranges would make the meter very flexible because it could now be used for many purposes. For instance, the plate currents of different types of tubes could be read on the milliamperes scales, and in testing certain types of dynamic speakers the current in the windings could be read on the 2 ampere scale, and with the 10 ampere range the charging current of storage batteries could be determined.

In regard to the proper scale to select on a meter when making any sort of electrical tests let us suggest that if you do not know the exact or approximate reading to expect it is advisable before connecting in the meter to obtain some idea of values from data on tests or experiments of a similar order. Remember that just the least bit of carelessness or oversight in improperly using a meter may result in a burned-out instrument unless it is protected by some means. Milliammeters in particular are often operated in conjunction with a suitable lamp or switch to protect the meter in the event of an overload.

ROUTINE PLAN FOR TESTING RECEIVERS. When servicing a receiver a good routine to follow, until you feel capable of working on your own initiative, is outlined in these paragraphs. First ask a few questions of the person who registered the complaint in regard to the set and its operation with the hope that some information will be obtained that will aid you in more quickly diagnosing the trouble. Then give the entire installation a careful visual examination. This means that you should look at the antenna and ground wiring and connections and all parts associated with these circuits, such as ground clamps, window lead-in straps, lightning arresters, and so on. Then closely inspect accessories of any description that may be used, such as socket-power devices, eliminators, relay switches and so forth and note their condition. Remember that many service complaints originate from improper installation of a set in the first place due mainly to the fact that in every line of work there are a few persons who make it a habit of neglecting important details because to them the details are seemingly unimportant.

Now, if everything is found to be in good order and properly connected, so far as you can see, then it will save much time if you next proceed to test all of

the tubes in the set by means of a tube checker or tester unless you are equipped with an assortment of known good tubes and wish to substitute these for the ones in the receiver. Many service men make it a practice when responding to a service call to first check the condition of all tubes of the set to be serviced before attempting to make tests or repairs of any kind. They do this because they know from experience a defective tube can be the cause of practically any faulty indication in the operation of a receiver and a large proportion of service calls are directly resultant from worn-out or impaired tubes. If you have not located the trouble thus far you could next check the source of voltage supply which may be either power line voltage, a-c or d-c, or the voltage of batteries according to the particular installation.

After you have completed the preliminary inspection as outlined in the foregoing paragraphs it is suggested that you now make a quick check of the suspected receiver by running a series of electrical tests at all of the sockets while the set is in full operation using for this purpose any standard set tester connected to the receiver as shown in Figure 1. This series of tests can be made with the chassis remaining in the cabinet. If any of the readings obtained at the sockets are at too great a variance with readings that should be indicated to provide satisfactory operation of that particular receiver then readings which are either high or low will guide you more or less closely to the circuit in which the defect may be found. Note that a set tester when in operation as pictured in Figure 1 tests tubes under the same conditions as exist when in their sockets.

A suggested order for checking through a receiver is to start with the power supply circuit which includes the rectifier. Then check each tube socket in turn in the order in which the signal passes through the set. In other words, after the power circuit and rectifier are carefully checked we suggest that you begin with the antenna stage, or 1st r-f amplifier socket, and take all of the voltage and current readings possible at each socket in succession until you finish up with the power audio-amplifier stage, or output of the receiver. By making a systematic check-up with a set tester it can be seen that certain important terminal voltage tests can be quickly made to determine whether power is being supplied to the set and whether the proper voltages exist at various points in the circuits. You should jot down the various readings at the time you observe them, it being best to use a special ruled form for this purpose about which we will discuss later.

If, after completing your preliminary examination and socket-analysis test as we have suggested and you then definitely decide that the trouble does lie in the installation, or power source, or tubes, or loudspeaker, or accessories such as socket-power devices if such are used, then it would be reasonable to assume that the difficulty rested in the circuits of the receiver itself. Your next step would be governed by conditions present at the time of the test and the nature of the complaint. For example, suppose the voltage values you obtained in the electrical tests agreed somewhat closely with values that were considered normal for that particular set and the service complaint was registered for "low volume" or "poor selectivity". With this information you would naturally look to the radio-frequency circuits and ascertain whether or not they are in exact resonance with one another. To place the r-f stages in resonance, or synchronism with one another you would either have to correct the alignment of the main tuning condensers or adjust

the trimmer condensers according to whatever work needed to be done to put the receiver in good operating condition. As a guide in deciding when the best adjustments are obtained in the process of synchronizing r-f circuits a progressive serviceman would use a modulated oscillator coupled to the antenna lead of the set to furnish a steady signal of uniform strength and, also, an output meter connected to the output of the receiver to provide an accurate indication of maximum output signal current.

Now, suppose you were reasonably certain from the nature of the complaint, or from any symptoms you may have observed during your preliminary check-up that the difficulty lay in the wiring or internal parts of the receiver then it would be necessary for you to run another series of tests, called continuity tests. If the set being serviced were in a cabinet it would be necessary to remove the chassis from the cabinet for convenience in getting at the parts and wiring for continuity testing. A continuity tester consists simply of a pair of headphones and a battery, or a voltmeter and battery. Most servicemen prefer to use the voltmeter method in continuity testing because it enables them to work with much more certainty by judging conditions from indications on a meter rather than from clicks or sounds heard in headphones.

With the continuity tester the condition of all wiring and connections can be checked for opens and shorts and grounds and the continuity of the windings of transformers, choke coils, resistors and so on can be determined. If a volt-ohmmeter were used instead of an ordinary voltmeter the continuity tester would provide a further check on such parts because it would give their resistance values directly in ohms and these values could be compared to the correct values specified by the manufacturer of the set. Let us mention that an ohmmeter is really a voltmeter whose scale is calibrated to read ohms and receives its power usually from a battery of suitable voltage.

Along with your continuity tests in hunting down troubles you will often find occasion to check tuning condensers and fixed condensers. Oftentimes a continuity test is not sufficient to prove whether or not a suspected condenser is O.K. and in such cases other methods must be employed for testing as explained in another lesson on this subject. As a rule continuity tests of the major circuits should be made first to determine whether these circuits are continuous or unbroken from one extreme end to the other.

To be sure that you understand what is meant by testing major circuits we will go into greater detail. Suppose that you decide to check entirely through a certain plate circuit with a continuity tester and to do this you place your test leads across extreme points in this circuit or, let us say, you place one test lead at the plate contact of the tube socket and the other test lead at some convenient but remote point in the plate circuit from the first test lead. In other words, try to span or include as much of this circuit as possible in your first continuity test. A good place to touch the second lead is at the point of attachment of this plate circuit to the voltage supply system. Then, supposing your tester indicated a closed circuit you would at least know the wiring or connections were not open or broken at any point. On the other hand, suppose the plate circuit were to test "open" then you would proceed to check each component part and all wiring from point to point until you found the trouble. An open in a plate circuit could be caused by a loose connection, a burned-out transformer winding, or if a plate resistor were used instead of a transformer the resistor might be defective. You will also find it necessary at times to check plate circuits where the - B

return side contains a grid bias resistor and this unit would be checked along with other parts in the plate circuit to determine its condition. The reason we mention the latter item specifically is because a grid bias resistor might be located in the extreme -B end of the plate circuit and when taking voltage readings you might get a reading of plate voltage at the tube socket and yet the wiring in the grid bias resistor might be open or burned-out. The voltage reading in this case would be obtained between the plate contact of the socket and the negative B output side of the voltage supply system. You can see that between the two points just mentioned you have not included that portion of the plate circuit from -B voltage supply to its point of attachment to the cathode or filament circuits. So, in this manner, you would consider each item in any circuit which you might test, plate, grid and so on.

This procedure is followed with all main circuits in an effort to isolate the trouble and once you know that it is located in a certain portion of the receiver you can narrow down the number of places where you feel justified in concentrating your efforts and using valuable time in getting at the exact cause of the difficulty. From our explanation in the preceding paragraph you can readily see that if an incorrect indication were noticed when checking any of the main circuits the one at fault would then be given a thorough check-up by testing from point to point along the wiring and connections and checking each individual part as found necessary according to prevailing conditions. This work should be done with the aid of a wiring diagram of the set. The manufacturers of many standard sets furnish tables of continuity test values which tell you the correct effects that should be indicated on your test outfit. If no readings or incorrect readings or indications are observed these tables should be consulted for they offer many suggestions as to the likely causes of different common troubles and, also, troubles that are peculiar to the particular set under examination.

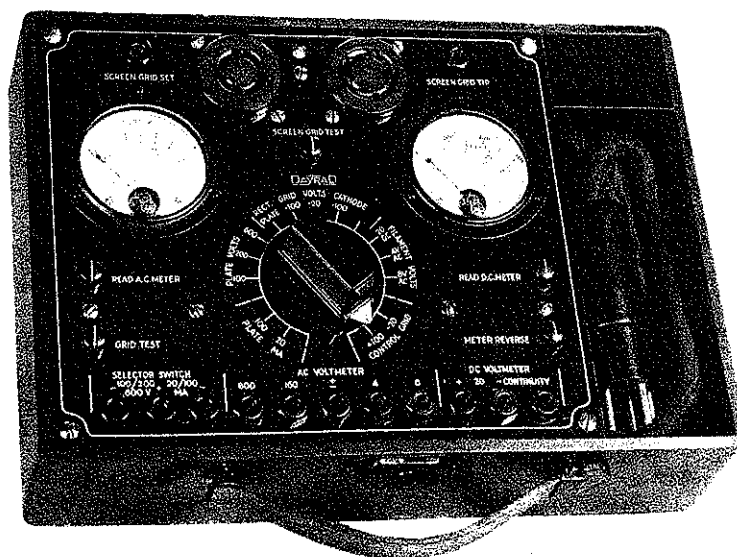


Figure 3

Before running a continuity test on a receiver you should first disconnect all power from the set, therefore, if a set were battery operated all batteries would be removed and if electrically operated the plug and cord would be removed from the socket or wall receptacle. It is also best to disconnect

the antenna and ground leads from the set and, before we forget it, let us mention that all tubes should be removed from their sockets during a continuity test.

Radio servicing when boiled down to a final analysis is a study of cause and effect and practically all faults and troubles in receivers are found by the process of elimination. We depend on the meter readings of our test equipment to help us find the cause of most difficulties. The set tester pictured in Figure 3 is provided with two meters as you can observe. Remember, however, a meter indication shows only the effect and, therefore, you should never be too hasty in forming conclusions as to the probable cause of trouble if a meter indication happens to vary a little from the value given on a data chart for the particular test at hand. Briefly stated, every trouble has its cause and displays a certain effect. It will be found that the majority of service complaints fall into a class called general troubles which includes items such as, low volume, poor selectivity, poor tone quality, noisy operation and so on. Again, let us mention that you should familiarize yourself with the details of the various well-known symptoms and their probable causes for the more common radio ailments as explained in our lesson on common faults and troubles.

Several examples of causes which produce the same effect are presented below in connection with the more common sources of a-c hum. First, let it be understood that a-c receivers have a slight characteristic hum which should not be noticeable at a distance from the loudspeaker. Excessive hum is usually caused by a defect in either the receiver proper or its tubes, of course, assuming that no electrical interference is entering the set from the outside. A strong hum is sometimes the result of a defective unit which may be either open or short-circuited while a light hum might be due to an unbalanced condition in one of the electrical circuits, for instance, from an incorrectly wound center-tap resistor, or from a power transformer which has developed a defect and whose plate winding delivers a higher voltage on one side of center tap than on the other. Other possible causes for hum are as follows:

1. Open, or ungrounded, or otherwise defective center-tap resistor.
2. Ungrounded, or open grid bias resistor.
3. Grounded filament circuit.
4. Defective audio-power tube.
5. Defective detector tube.
6. Shorted grid by-pass condenser.
7. Loose laminations on filter choke.
8. Defective rectifier tube.

By systematically checking through outlines similar to the one given above, but dealing with different complaints, it will no doubt help you in most cases to solve the usual problems encountered in servicing receivers and thus eliminate the necessity of making further and more time-consuming tests.

Bear in mind that all voltages are interdependent to a certain extent. To cite an example: Suppose the voltage at some point in a receiver is zero, which for the sake of explanation is, let us say, the heater of one of the r-f tubes; then the a-c voltages at the heater terminals of all other tubes

energized from the same source as the defective heater will be high. Or, to cite another example; Suppose the plate of a 245 power tube were open and its voltage were zero; then upon measuring other plate voltages they would be found to be somewhat higher than normal. And so, we could go on indefinitely giving many combinations of causes and their effects.

Another thing to keep in mind when testing circuits is that one faulty part may cause the breakdown of some other part and when cases of this kind are met in servicing you should not only replace or repair the defective part or parts but you should also be sure to correct the underlying source of the trouble. If you neglect to follow this advice the same trouble might occur again in a short time and the receiver would then need further servicing for the same complaint. When a thorough inspection and electrical analysis of a faulty receiving set is made in accordance with some definite plan like we have just described it will not only make your work easier but it will prevent delays which would be caused through unnecessary dismantling of the set or in taking things apart in general. Let us give you a word or two of advice on testing—do not jump at conclusions—on the other hand, always make your tests accurately, use any available diagrams, charts or tables that will assist you in this work and consider your test indications carefully with reference to the nature of the complaint. If you couple this advice with the application of a little sound reasoning and common sense you will know what you are doing and will be able to correctly diagnose and treat radio troubles.

USE OF CHARTS AND TEST DATA. In view of the wide-spread popularity of receivers operated from a-c power lines the present day serviceman must at times make use of the electrical data given in manufacturer's service manuals or of similar data supplied by the makers of electrical instruments. Consequently, we will say a word or two about measurements and the purpose of a radio set chart of voltage and current readings which is usually called an "analytical chart". The use of a set tester permits readings to be taken while the receiver is in operation and the readings, therefore, represent load conditions, a knowledge of which is, in most instances, necessary to locate trouble. These charts are of the greatest value when investigating a radio set for trouble when used in conjunction with the radio set tester. A sample analytical chart will be found below in Figure 4. By making an

TABLE OF SOCKET VOLTAGE AND CURRENT READINGS FOR AN AVERAGE RECEIVER							
Type of Tube	Position of Tube	"A" Volts	"B" Volts	"C" Volts	Screen-Grid Volts	Plate M.A. Normal	Plate M.A. Grid Test
Y-224	1st R-F	2.4	175	2.5	70	3.5	6
Y-224	2nd R-F	2.4	175	2.5	70	3.5	6
Y-224	3rd R-F	2.4	175	2.5	—	3.5	6
Y-227	Detector	2.4	290	27	—	2	—
X-245	Audio P.P.	2.4	250	45	—	30	50
X-245	Audio P.P.	2.4	250	45	—	30	50
X-280	Rectifier	4.8	—	—	—	55	—
L.V. (Line voltage) = 115				VOLUME CONTROL = Maximum position			

Figure 4

analysis of a receiver a complete set of readings is obtained, which may be analyzed as a whole and measures may be taken if necessary to correct any existing difficulty. Thus, the measurements taken on set testers in general tell the serviceman whether the principal circuits of a receiver are operating within certain high and low levels of voltage and current values. Just what electrical values are to be maintained for any particular receiver should be taken from the service data charts and tables furnished by the manufacturer of the set since values given by the manufacturer are preferred to those obtained in any other way.

When the readings listed in Figure 4 were taken the particular radio receiving set to which they apply was operated under ordinary conditions with the volume control in "full on" position throughout the test and at a time when the a-c line voltage was 115 volts. The plate voltages were measured from plate to cathode, grid voltages were measured from grid to cathode and screen-grid voltages were measured from screen-grid to cathode. Observe that tubes in a similar position in the set show similar readings when normal conditions exist.

We must be careful when interpreting the readings obtained in our electrical tests. The values given in analytical charts, like the one in Figure 4, are ordinarily to be taken as an average for normal operating conditions and, therefore, these values do not represent exact values that you must strive to obtain when servicing a faulty receiver. Hence, the electrical values that should be indicated on test meters placed at different points throughout a receiver can only be approximate ones since variations will be caused by tubes and line voltages. As a rule unless the measured voltages differ by more than 25 per cent from those given in the chart for the particular receiver in question it should not be taken as a definite indication of a fault. However, any deviation greater than 25 per cent usually means trouble.

If the values recorded on a chart were taken on a set operating on a 110 volt line and if the same set, or another set of the same model were attached to a 115 volt line then it is only natural to expect that the measured voltages would differ from those given in the chart in approximately the same ratio, or the ratio of 110 to 115. It should now be clear that all the values found in charts made up for this purpose are to be used only as a basis of comparison. It is important for the student to understand that voltage and current readings obtained in checking circuits are dependent also on the type of meters employed, but since the values on our charts are only approximate to begin with then it is safe to say that when meters of any of high-grade make are used, the indications will be sufficiently accurate for this class of work. It is suggested that in commercial servicing a record of the condition of a set under test be made on a form arranged similarly to the chart in Figure 4. Such a record may prove valuable for future reference and, at least, it will help you in your work on the particular job at hand since individual readings are difficult to remember for purposes of comparison, especially with present-day receivers.

RADIO SET TESTERS IN GENERAL. Since tube testing and set testing by analysis of the voltages and currents at the various sockets of a receiver have been daily growing in importance and are now considered two of the principal phases of radio servicing it will be of special value to you in your studies of this subject to have a general knowledge of the operation of

standard commercial instruments with diagrams showing the layout of circuits designed expressly for this work. After carefully studying the text and diagrams which are to follow you will learn that service equipment has become highly standardized and practically the same principles are incorporated in the various testers to provide readings of an identical kind. That is to say, each tester provides some convenient means for making the meters available for external measurements, for example, through the use of binding posts, pin jacks, switches and so forth. To explain further, suppose for example, a meter in one particular tester were used to give a reading of plate voltage during a socket-analysis test then if another instrument were used to take a similar reading the circuits of this instrument would be arranged to connect electrically in the tube's plate circuit like the first instrument. Hence, a socket-analysis of a receiver would be conducted with any of the instruments described in this section according to the general plan explained in connection with Figure 1.

An examination of the photographs in Figures 5 and 6 will give you a clear idea of how the meter ranges compare on a two-meter and a three-meter set tester of standard design. These descriptive views, which are labelled in such detail that they are practically self-explanatory, are of Weston Electrical Company instruments, models 566 and 565 respectively. Model 565, besides being a complete set tester, is designed to provide additional tests and its circuits include an oscillator, a double-range direct reading ohmmeter and a tube checker which gives reading of a-c and d-c values for this purpose.

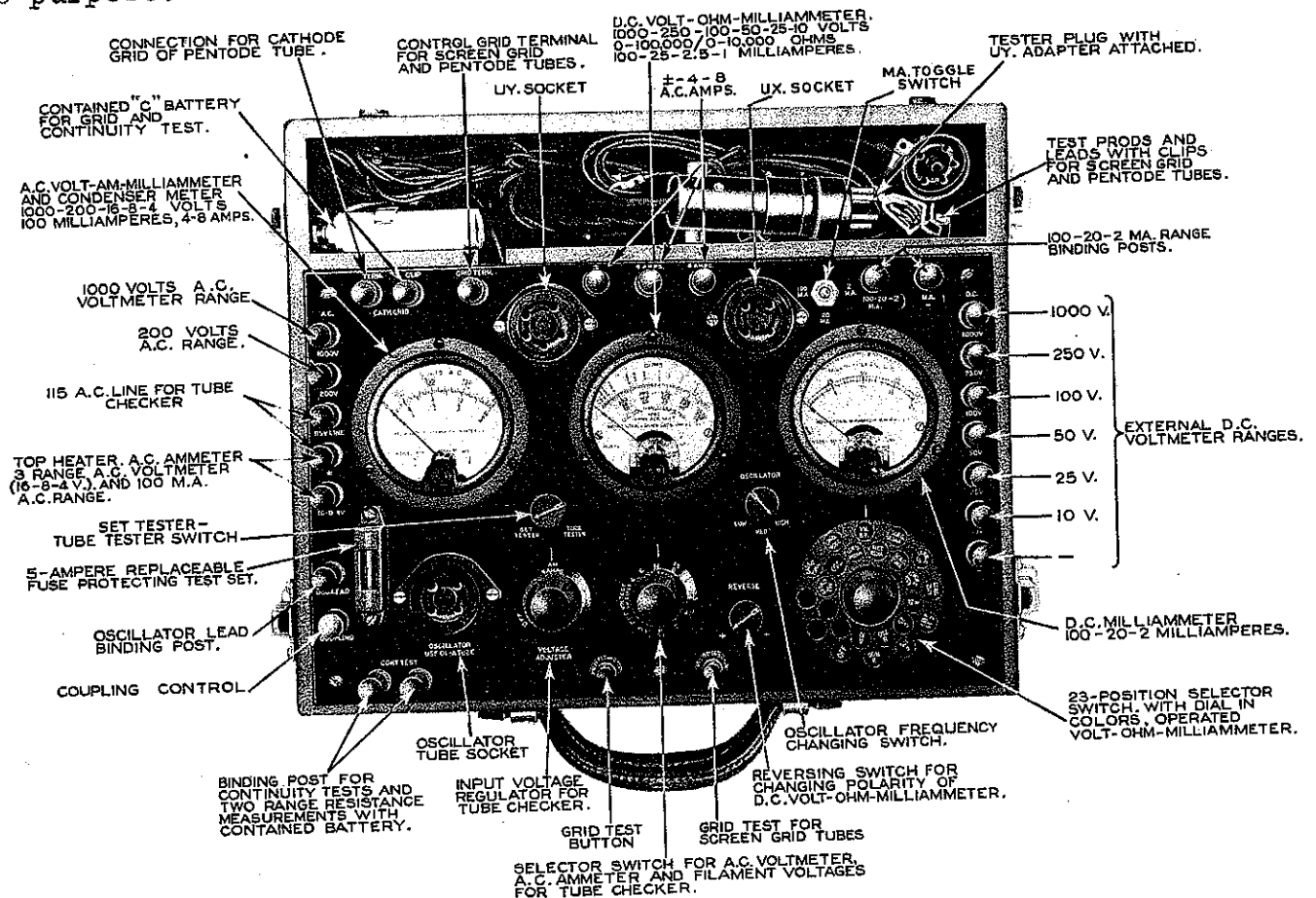


Figure 5

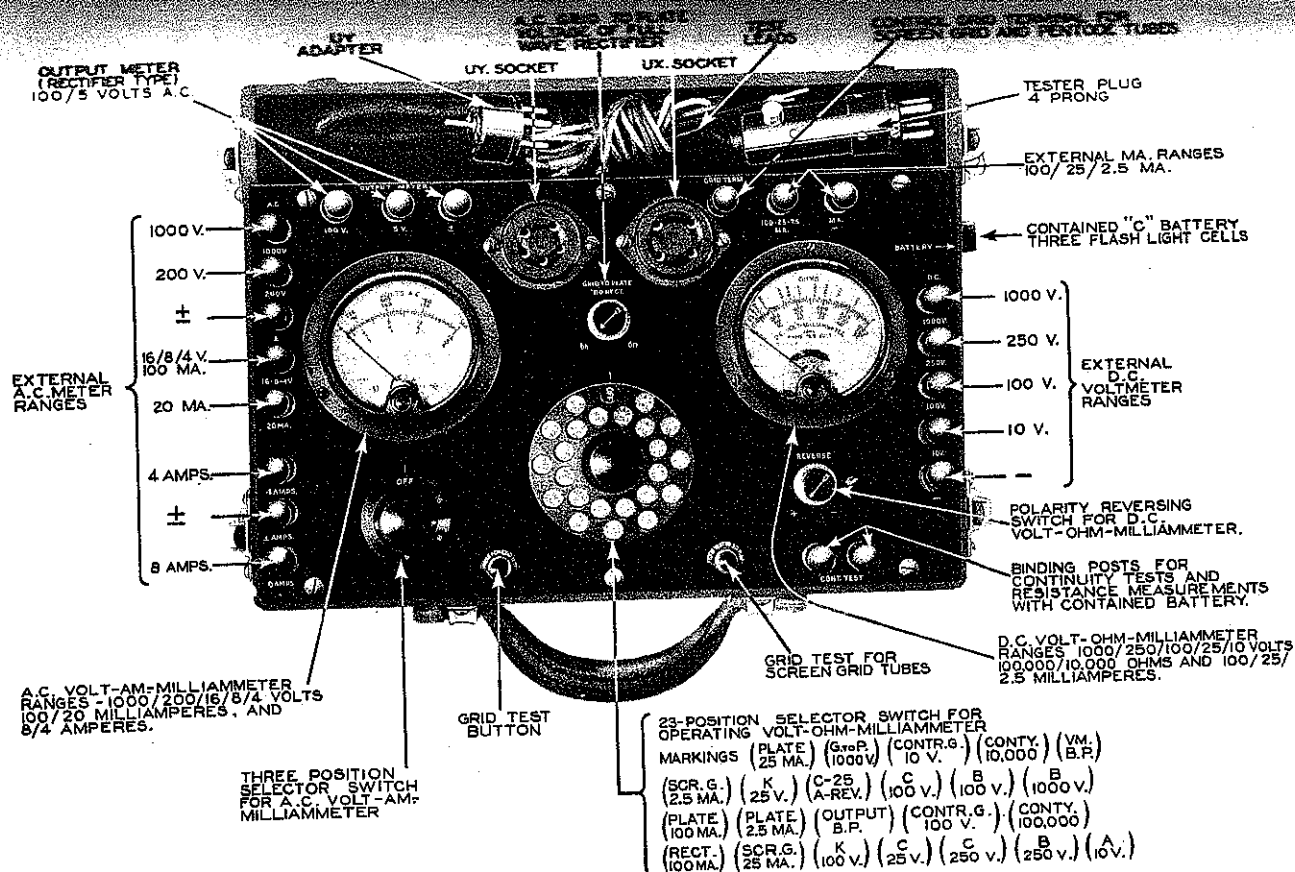


Figure 6

A few of the tests that may be performed with the Weston tester in Figure 6 will now be explained. One series of tests that can be run with the tester plug inserted in different sockets of a radio set and the tube inserted in the proper socket in the tester are as follows:

The ± 10 volt range of the d-c voltmeter would be used to read filament voltages, and the 4, 8, or 16 volt range of the a-c voltmeter would give both heater and filament voltages of a-c tubes. Plate voltages could be read on the 250 or 1,000 volt range of the d-c voltmeter. To provide bias voltage readings at the tube base you would use either the 10, 25, 100 or 250 volt range of the d-c voltmeter according to the circuit conditions. The cathode voltages in these tests would be read on the 50 volt scale of the d-c voltmeter while for control grid voltages you would connect in one of the scales on the d-c voltmeter, either the ± 5 or ± 100 volt range. Screen current could be read on the 2.5 or 25 m.a. range of the d-c milliammeter, plate current on the 25 or 100 m.a. range of the d-c milliammeter, and the d-c milliammeters could also be used to measure the plate current of full-wave rectifier tubes giving simultaneous readings on both plates.

Other tests which make use of the meters through the voltage and current binding posts are called external tests. For such purposes the test circuits and meters may be used to check tubes; provide resistance measurements on the scales calibrated in ohms; function as an oscillator and so on. The next few paragraphs are devoted to detailed explanations on the use of meters and scales to give you practical ideas which you should know about concerning typical metering equipment.

Measurement of the a-c line voltage supply is made on the 200 volt range of the a-c meter in Figure 6, while the higher range, or 1000 volt scale can be used to measure the a-c voltage across a power transformer secondary winding from its center tap. One of the ranges of the a-c meter, either the 4, 8, or 16 volt scale, would be used to read the heater voltage at a power pack. The plate current in any portion of a receiver could be measured at various "B" supply taps by using either the 20 or 100 m.a. scales of the d-c milliammeter. The d-c voltmeter would provide readings of the "B" supply at power packs by using either the ± 250 or ± 1000 volt range. To check the condition of all types of radio batteries, known as "A" "B" and "C" batteries, you would use one of the d-c voltmeter scales, either the 10, 25, 100, or 250 volt scales.

To make a continuity test of a complete circuit or some individual part of a circuit the continuity test circuit would be put into use. This circuit consists of a self-contained 4.5 volt battery arranged in series with the d-c voltmeter which can be operated to provide a resistance of either 100 or 1000 ohms per volt as desired. The resistance ratio best to use in any case to get the most accurate reading would be determined by whether a high or low resistance was to be measured. This voltmeter is calibrated as a direct-reading ohmmeter with ranges of 0-10,000 and 0-100,000 ohms and, hence, when making continuity tests the resistance indications obtained serve as a further check on the parts being tested. You can measure the line current input of an a-c set on the 4 ampere range of the a-c ammeter and for small a-c measurements such as currents in the voice coil of a speaker either the 20 or 100 m.a. range of the a-c milliammeter would be employed.

When a service call is answered and it is found that a receiver must be neutralized, or synchronized, or tested and at the time there is no signal on the air, or if there is one and it is not sufficiently steady or constant in strength to serve as a guide in making fine adjustments, then the modulated r-f oscillator is brought into play and with its three frequencies covering the broadcast band the work can be completed satisfactorily and without interruption. An output meter which may be connected into the output of a receiver, that is, to the output of the last audio stage, is supplied with a self-contained current transformer for checking the output of a set, making comparison of signal strengths and so on. A grid-dip meter is also provided for indicating when resonance is obtained between radio-frequency circuits. The tube checker features incorporated in this type of instrument permits all filament and heater-type tubes to be tested with power obtained from the a-c line.

A summary of the explanations on the use of various instruments in a typical set tester, such as the one pictured in Figure 6, shows that only three meters are actually required because each meter is equipped with a multi-scale dial. For example: The a-c meter reads volts, amperes and milliamperes in the following values, 0-4-8-16-200-1000 volts, 0-20-100 milliamperes and also 0-4 amperes. One of the d-c meters reads volts, ohms and milliamperes in these values, 0-5-10-25-50-100-250-1000 volts, and two resistance scales calibrated for 0-10,000 and 0-100,000 ohms respectively, and, also, 0-1-2.5-25-100 milliamperes. A second meter, which is a d-c milliammeter, has two ranges reading 0-20-100 milliamperes.

Another standard type of set analyzer which is provided with but one meter and a selector switch to connect the various meter ranges to the circuits is illustrated in Figure 7. You will observe that only two scales are printed on the meter dial but 22 ranges are available since higher ranges are read by merely multiplying the pointer indication by 10 or 100 as the case may be. This instrument is a Supreme set analyzer having five ranges for readings of plate current, grid current, screen-grid current, plate current of 280 rectifiers and so on, and six ranges each are available for d-c plate voltage, d-c filament voltage, cathode voltage, control-grid voltage, screen-grid voltage, the a-c voltage supplied to the plates of 280 rectifiers and so on. All voltage readings, both a-c and d-c, are available in the following ranges: 0-3, 0-9, 0-30, 0-90, 0-300, 0-900. All current readings, both a-c and d-c, are read in milliamperes in the following ranges: 0-3, 0-9, 0-30, 0-90, 0-300. The various pin jacks located on the panel serve to make connections to the meter ranges for use in external testing. A single meter which reads both a-c and d-c values like the one in Figure 7 has a copper oxide rectifier incorporated in its design.

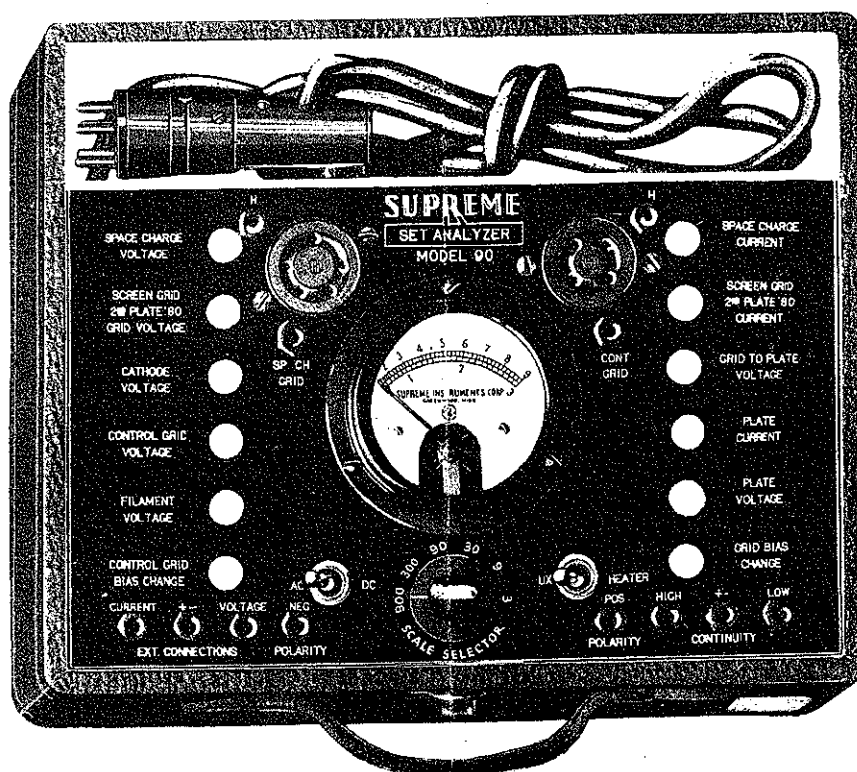


Figure 7

Another instrument that provides a great many combinations between its circuits and meters is the Supreme three-meter tester illustrated in Figure 8. Besides the pin jacks shown on the panel there are a number of other pin jacks located on the back side of the instrument through which access can be made to all of the apparatus contained in the instrument for external use. On the left of the panel you see the oscillator coil in place and when the circuit which employs this coil is operating a modulated signal is furnished to a receiving set for testing purposes. Arranged in front of the instrument are a number of miscellaneous parts, such as test prods or points, tester plug with cable attached, adapter,

jumper leads, screen-grid leads and so on, all of these being required in making various tests. When this analyzer is plugged into the last audio-amplifying stage of a receiver and the proper switches are manipulated the action of the milliammeter on the panel is a fair guide as to the degree of distortion in the audio circuits. When a signal is coming through the receiver and its circuits are functioning correctly the needle should remain steady regardless of the fluctuation in signal strength. If the needle should deflect upward with the signal impulses we would know that the "C" voltage was too high for the "B" voltage being used, or it might be the other way around, that is, the "B" voltage might possibly be too low for the "C" voltage being used. Remember that a test of this kind gives an accurate guide of circuit conditions only when the tubes in the receiver are in good condition. If the reading on the output meter gave a noticeable deflection, by considerable movement up the scale under such conditions, you should proceed to make adjustments in the case of an electric set, if any adjustments were provided, to obtain normal results. An unsatisfactory indication on the output meter when it is connected to a battery operated set would most likely be due to worn out batteries and if such was found to be the case then, obviously, a renewal of batteries would be in order. Let us suggest that whenever "B" batteries are replaced it is a good plan to renew the "C" batteries at the same time.

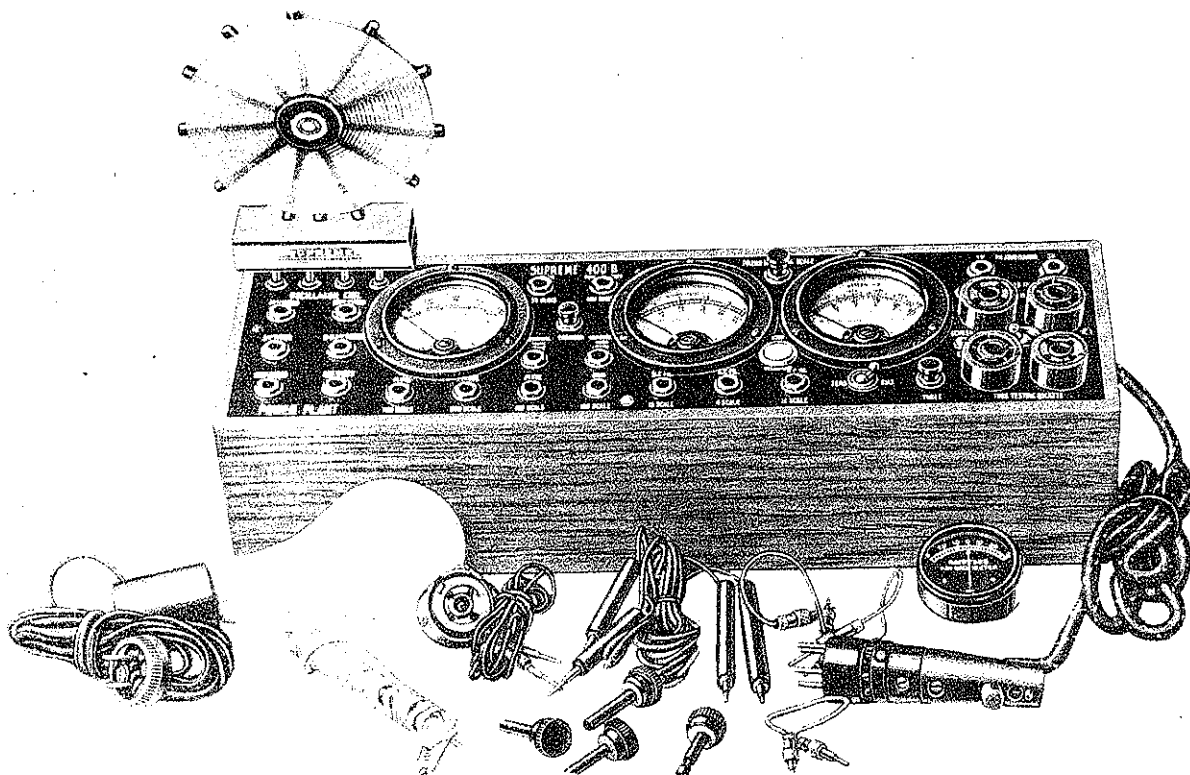


Figure 8

The diagram in Figure 9 gives the circuit connections and parts in a Jewell set analyzer model 199. This diagram will help you to a better understanding of your work in servicing receivers since it shows the method of arranging switches or buttons to make the scales on the meters available for various tests. A front view of this Jewell set analyzer is given in Figure 10. It shows the different push buttons just referred to for obtaining

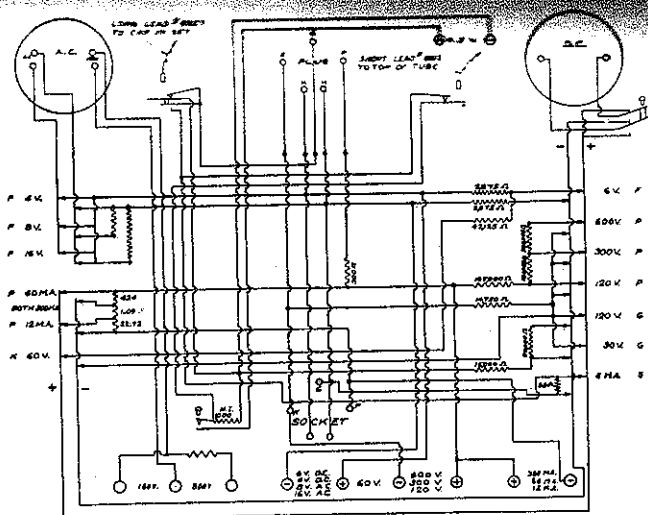


Figure 9

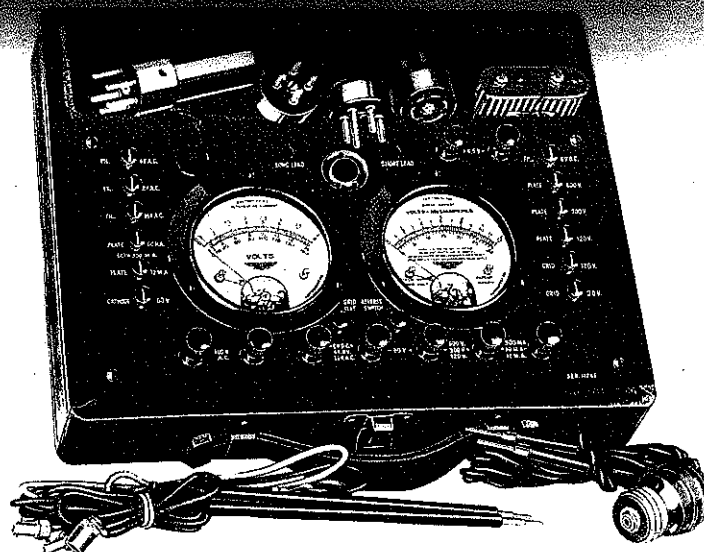


Figure 10

readings on any desired range provided by the two meters. The a-c volt-meter is located on the left and it has readings of 0-4-8-16-160 volts to meet the needs of a-c radio testing. On the right is the d-c meter which has ranges of 0-6-30-60-120-300-600 volts and 0-12-60-300 milliamperes. The voltmeter's resistance is 1,000 ohms per volt and consequently it draws but such a very small current that voltage readings can be made without distortion of set conditions. The small "C" battery shown at the upper right can be easily replaced by means of the two short leads which run to the 4.5 volt binding posts. This battery is so wired in the analyzer circuit that when a grid test of a tube is made the battery is placed in series with the grid circuit which causes the grid potential to shift 4.5 volts positive. This is sufficient change in grid potential to affect the electron stream passing to the plate and, hence, this test gives a very definite change in plate current indicating in a general way whether or not a tube is in good condition. Of course, for some purposes outside the scope of radio servicing it may be desirable to know the all-around performance or characteristics of a certain tube and in this case it would be necessary to express the condition of the tube in terms of amplification constant and mutual conductance.

The set analyzer illustrated in Figure 3, which has been referred to before, may be used to make routine tube-socket tests as we have just mentioned and, in addition, this tester has a continuity test circuit which may also be used to measure resistance by the fall of potential method. To find the resistance being measured at any given throw of the meter pointer, the meter reading is noted and a chart for this particular set tester, which is a DayRad instrument, is referred to and the resistance determined with a good degree of accuracy. When testing radio receivers, the various d-c voltmeter-milliammeter and a-c voltmeter readings may be noted as follows: The filament or heater voltage, either a-c or d-c, the plate voltage, the grid-bias voltage, cathode voltage, plate current, screen-grid voltage of screen-grid tubes, control-grid voltage of screen-grid tubes and, also, the readings necessary in the grid test which is used to get a rough check on tube condition. The selector switch shown on the panel of the tester in Figure 3

is used to select the proper scale of either meter and no reading is had until the meter push-button is depressed. This eliminates the possibility of damaging a meter by operation of the selector switch. On the d-c meter are the following six ranges: 0-20-100-200-600 volts and 0-20-100 milli-amperes and on the a-c meter are four ranges: 0-4-8-16-800 volts. All ranges of both meters are available externally through tip jacks at the lower edge of the panel. In addition to the above tests, the tester may be used to test plate voltages of the helium non-filament type rectifier as well as the 280 and 281 filament type rectifiers.

DETAILED EXPLANATION OF A TYPICAL SET TESTER AND ITS USE. The first part of our lesson contains sufficient instruction about set tester equipment and practical diagrams to give you a good general knowledge of the subject. Now we will go into a more detailed discussion of one type of set tester to explain just how it would be used in practice and what tests could be made with it. The instructions, therefore, in this part of our lesson have been written in considerable detail because of the many factors involved in radio set testing. For this purpose we will use the diagram in Figure 11 which illustrates one type of Weston instrument. With the circuit in Figure 11 the various a-c and d-c voltages normally supplied by batteries, or electric power supply units to operate receiving sets can be measured and the tubes can be tested under the same conditions as exist in their sockets. This diagram illustrates the use of bi-polar selector switches and dials for connecting in the various meter ranges with circuits when making tests. Also, the diagram shows how the wires in the cable attached to the tester plug go to the contacts of the UX and UY sockets and to other parts of the tester circuit.

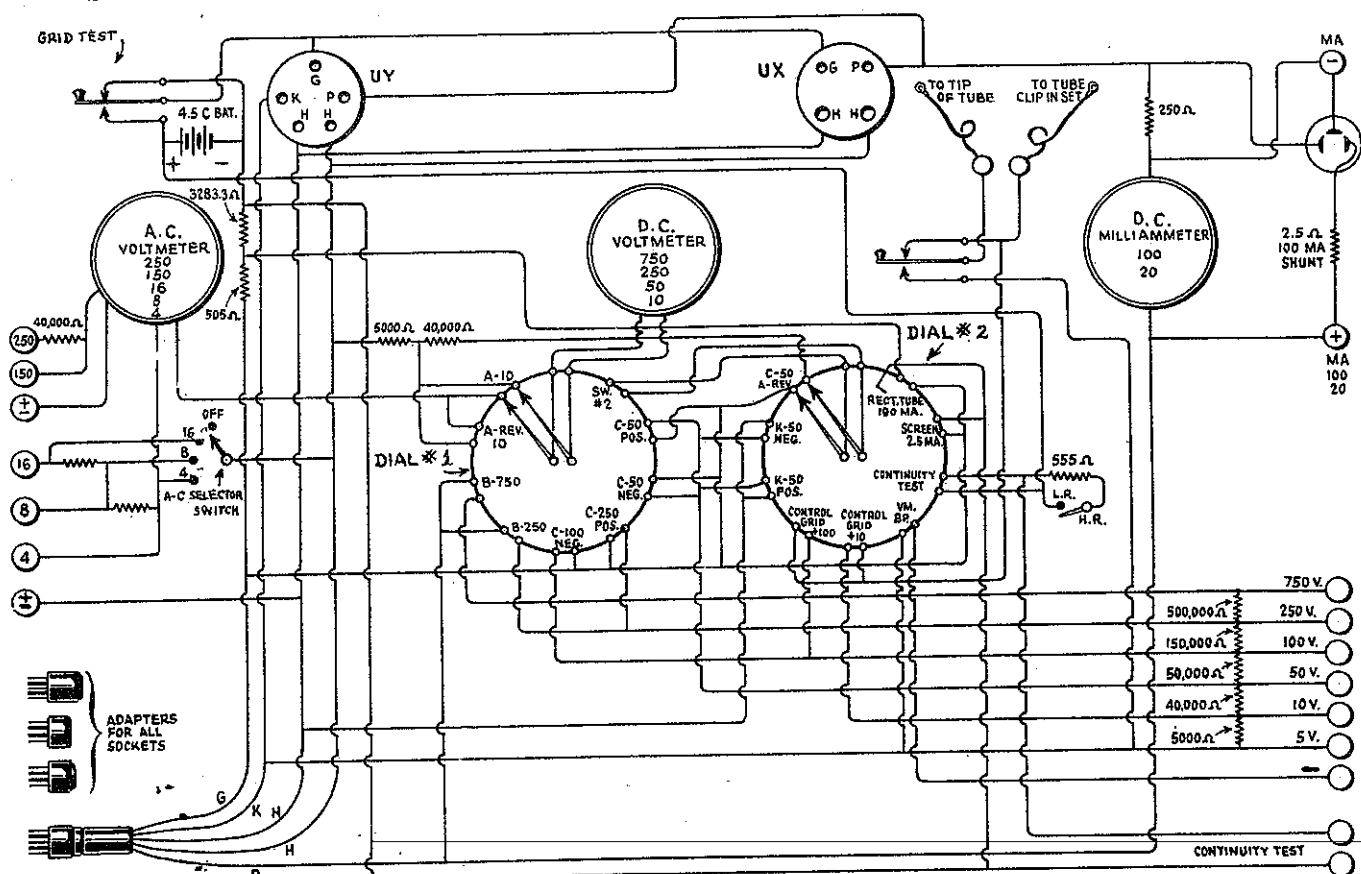


Figure 11

Several adapters are shown which are needed to make tests on various types of 4 and 5 hole sockets. This is a practical example of one way of arranging the component parts; such as the shunt and multiplier resistors, the continuity test circuit, the grid test consisting of the "C" battery and switch in the upper left corner which is used for determining the general condition of a tube and, also, the group of binding posts placed around the panel which allow the meters to be used independently of the tester itself for any measurement purposes, of course, within the ranges provided by the meters. When using the binding posts the tester plug should not be connected to the radio set.

As indicated on the diagram in Figure 11 there are three meters used to provide readings. The two switches, marked dial #1 and dial #2, are arranged so that the meters cannot be connected across any two circuits at the same time and, hence, for all readings on dial #2, dial #1 must be placed in position "SW. #2."

The a-c voltmeter has the following ranges: 0-4-8-16-150-750 volts. Any of the three lower ranges can be connected directly across the filament terminals of the tester plug by placing the selector switch on the contact which provides the desired range. These lower ranges are for the purpose of measuring the filament or heater voltages of tubes whose filaments are heated with unrectified alternating current, or, as stated before, current known as raw a-c. With the 150 volt range you can measure a-c line voltages and with the 750 volt range the high a-c voltage of power transformers can be checked.

The d-c volt-milliammeter in the center of the diagram has 8 ranges as follows: 0-5-10-50-100-250-750 volts and 5 and 100 milliamperes. The 250 and 750 volt ranges are for plate "B" voltage measurements; the 5, 50 and 100 ranges are for grid bias readings but the 50 range may also be used for cathode voltage readings; and the 5 volt range is especially suited for use in making continuity tests. The 5 milliamperage range is sufficiently low to provide good readings of screen-grid current of screen-grid tubes and the 100 milliamperage range is suited for plate current readings of rectifier tubes. The d-c milliammeter at the right has two ranges, 20 and 100 m.a., either one of which may be used by placing the toggle switch in the 20 or 100 positions.

In one of the foregoing paragraphs we said that whenever a receiving set is to be tested you should place the set in as near good operating condition as possible by making such adjustments as are normally required to bring in a signal and after making various electrical tests explained in our lesson you will know the location of any existing trouble and be in a position to tell whether it is in the receiver circuits, in the tubes, or in the power supply system.

Each step in this check-up of a troublesome receiving set is explained in the following paragraphs according to a plan we will now outline. By studying from a plan of some sort, such as this one, our students will be better able to understand the numerous factors that must be considered in work of this description. The plan suggested for analyzing the various receiver circuits which are directly supplied with power is given on the following page.

The plan for a systematic check-up of receiver circuits is as follows:

1. Checking Power Supply to Radio Set; Testing Batteries, Eliminators, Power Packs and so on.
2. Checking Receiving Set Circuits.
 - a. Rectifier circuit analysis.
 - b. Plate " "
 - c. Grid (control) " "
 - d. Screen-grid " "
 - e. Cathode " "
 - f. Filament-Heater " "
3. Tests on Tubes.

(1) Checking Power Supply to Radio Set. The first electrical test or check on a receiving set should be on the power supply to make sure that the circuits of the receiver are being supplied with their proper operating voltages. This check would be made on either batteries, eliminators, power packs, socket-power devices, a-c or d-c supply lines, or, in other words, on whatever source of power supply was being used to operate the set.

To make these tests the voltmeters in the diagram in Figure 11 are used independently of the tester circuits and, therefore, the tester plug is not to be inserted in any socket of the receiver at such times.

To take measurements of sets operated from direct current the center meter is connected to the d-c voltmeter binding posts by setting dial #1 to position marked "SW. #2" and setting dial #2 to "VM. BP." Then by attaching two flexible test leads to these posts the center meter could be used as a multi-scale d-c voltmeter to measure the input or output voltage of a d-c circuit or the voltages at different points throughout a d-c circuit. Let us caution you never to be careless in checking power circuits and take chances on receiving a shock by permitting your hands to come in contact with any part of the circuit. A point to remember is that if in d-c work a color scheme were used for test leads the black cord should be attached to - minus binding post and the red cord to whatever + plus binding post would provide the scale desired, 5 or 10 or 250 and so on.

If a receiver is battery operated the condition of the various batteries would be checked by making use of the test leads connected as suggested in the foregoing paragraph. It would be better to test the batteries with the set turned completely on, if this is practicable, in order to place a load on them. They should then give approximately their rated voltage readings, and if any batteries are found to be too low for proper operation they should be replaced or recharged as the case may be. In checking through the battery operated radio set be sure the batteries are properly connected and that no weak batteries are allowed to remain connected to the set when you complete your service call. Also, don't forget to adjust the filament rheostat if one is provided so that the tube filaments will get their correct working voltage when you test a battery set.

If a receiver is electrically operated from a d-c house lighting main the line voltage should be measured to make sure that it is correct for the set. For this measurement test leads are connected to "-" and "250" binding posts. If a receiver is supplied with power from an a-c house lighting circuit and it is desired to measure the line voltage then the a-c voltmeter is used by

attaching the test leads to the pair of a-c binding posts marked "+" and "150" respectively, and, of course, this range can be used to check a-c voltages in any circuit when not greater than 150 volts. The test leads would be attached to the a-c binding posts "+" and "750" respectively, to measure the high voltage of plate supply transformers up to 750 volts either side of center tap. In regular service work you will meet many sets that were originally designed for battery operation but that are being powered from socket-power devices connected to a-c lines. If you find, when testing radios in this classification, that there is a radical departure from the specified current reading it usually indicates a defective tube, or improper relation between the "B" and "C" voltages of the radio. The latter is not an unusual trouble where socket-power devices are attached to radios originally designed for battery operation. Wherever this trouble is encountered, the "B" voltage should be adjusted to the proper value for the "C" voltage used. Otherwise, the tubes will be subjected to strenuous usage and the reproduction will not be satisfactory in quality.

In the case of an alternating-current radio set the input to the power circuit, or primary circuit of the power transformer, should be adjusted to the existing line voltage if there is some means provided for making an adjustment of this kind. The majority of a-c sets are equipped with either a switch or two sets of fuse clips and fuse for connecting the line supply to the high "HI" or low "LO" positions of the power transformer input. It is customary to use the "LO" position for line voltages of 100 to 115 volts and the "HI" position for 115 to 135 line volts.

After you are assured that normal voltage is being supplied to the receiver from the source, whether it be from batteries, a-c or d-c power mains and so on, then you should proceed to make an analysis of the various circuits of the receiver, beginning with the rectifier portion of the set, as we previously explained.

(a) Rectifier Circuit Analysis. The electrical test at the rectifier socket of a receiver is made by removing the rectifier tube and placing it in the UX socket of the set tester and then inserting the tester plug in the rectifier's socket. When a rectifier tube of the filament type is to be tested with the circuit in Figure 11, first turn dial #1 to position marked "SW. #2" and then turn dial #2 to "RECT. TUBE-100 M.A." and, also, set the milliammeter toggle switch, shown in the upper right of the diagram, to 100 m.a. Remember, however, that not until the dials are properly set should you insert the tester plug in the rectifier socket and the tube in the set tester socket.

When running a test like this one any reading which you would observe on the milliammeter would be the total direct current output of the tube if it were a half-wave rectifier, or one of the '81 type; but if a full-wave rectifier were being tested, or one of the '80 type which has two plates and two filaments, the milliammeter will indicate the plate current in one plate and the meter in the center will indicate the current in the other plate. Hence, to get the total current with a full-wave rectifier tube in the socket the two plate current readings should be added. A tube in good condition should give plate readings which are very nearly alike and if any difference is observed between them it is an indication that the emission of one filament is lower than the other, or perhaps the voltage on one plate is quite different than the other.

To read the filament voltage of the rectifier tube with the circuit in Figure 11 you would set the dials in the positions as for measuring filament voltage of any type of tube.

The rectifier circuit analysis tells many things about the power supply units. For example, if all readings are found to be normal you can be assured that the a-c line voltage is correct and the power transformer primary is O.K. and, also, that the secondary winding which supplies the rectifier filament voltage is supplying its rated a-c output and, furthermore, that the tube is in good condition.

The next step, after having checked the line voltage and source of power in the set or the rectifier, would most naturally be to check the voltages and currents supplied to each tube and, as we said once before, the most logical order to follow in a series of tests is to take each socket in turn in the order in which the signal passes through them. Hence, we would begin with the 1st r-f stage or input from the antenna and proceed through the receiver from socket to socket ending with the output or power audio-amplifier stage.

(b) Plate Circuit Analysis. The plate current under load conditions is a very good guide to general conditions since the current flow in this circuit is the result of the potentials supplied to the tube's electrodes. The plate current reading obtained on the d-c milliammeter gives the value of this current normally passing through the tube and plate circuit connecting to the particular socket at which a test is being run under the several factors then existing which govern this flow, namely, plate voltage, grid voltage, filament or heater voltage and screen-grid voltage and so on depending upon the type of tube used. One of the most common variations in a tube's values, found in testing, is the deviation of plate current from normal. By reading the values given on a service voltage and current chart, or if one is not at hand then you could use the table of tube characteristics as a guide in determining the approximate relation between plate volts, grid volts, plate current and so forth, or you could refer to our table of values.

When using the circuit in Figure 11 the plate current is read on either the 20 or 100 m.a. range of the d-c milliammeter by setting the toggle switch used for this purpose to whichever side is desired since the meter is connected in the plate circuit at all times. A more accurate reading is always obtained by using the range on which the greater deflection of the meter's needle is obtained.

The student should understand that it is not quite so important to have the plate voltage any exact value as it is to have the "C" voltage properly proportioned to it. To cite an example to make our point clear, suppose the plate voltage on a 171 tube were 172 volts instead of 180 volts, no noticeable difference in set operation would result providing the grid voltage was reduced a certain amount so that a current value a little under 20 milliamperes would be obtained. To get this result would require that the grid voltage, which is ordinarily about 40.5 volts for a 180 volt plate potential, be lowered to approximately 38 volts. Always bear in mind, however, that you should follow the manufacturer's specified values in regard to circuit requirements. Thus, if the plate current is very much different from

what it is supposed to be under the conditions existing at the time of the test and for the tube being used then you should endeavor to restore any incorrect voltage more nearly to its normal value. It will be found that decreasing the grid potential applied to a tube will have more effect on increasing the plate current than will be had by any reasonable increase of plate potential providing, of course, other factors remain equal.

In making a check on the plate supply and circuits of sets it will be noticed that a voltage reading obtained with a tube in its socket which places a load on the voltage supply circuit will be less than the reading obtained with the tube out of its socket or without the circuit loaded. The reason for this difference is simply that there is a certain IR drop, or current-resistance drop, called voltage drop, in any circuit through which current is flowing and this is the case in a "B" supply device. As a rule when this voltage drop is much greater than 1 volt for every milliamper drawn by the tube then steps should be taken to adjust the voltage of the power unit. If the set is battery operated it will require the replacement of the "B" batteries, or if the set is an electric one the rectifying tube may need replacing.

In most socket power devices means are provided for adjusting plate voltage to any value specified for a certain tube or socket which is under test. Plate voltage is read directly on the d-c voltmeter in Figure 11 by setting dial #1 to either "B 250" or "B 750" according to the scale desired and, as we said before, use the one on which the voltage can be read with the greatest accuracy.

Some of the more common troubles that might cause improper reading to be obtained on the plate voltmeter and milliammeter are a defective rectifier tube; open primary winding of a transformer; open series plate resistor; loose connection in the plate circuit or an open or poor connection somewhere in the tube socket or tube's prongs not making good electrical connection with the socket contacts; shorted by-pass condenser; or weak or exhausted "B" batteries.

(c) Grid Circuit Analysis. Note that this analysis deals with the grid in three-electrode tubes and the control grid in four-electrode or screen-grid tubes which, in either case, is the grid and circuit that is supplied with the signal voltage. The reading obtained for this test gives the negative bias on the grid with reference to the filament or cathode.

To read "C" bias voltage with the circuit in Figure 11 set dial #1 to the position marked "Neg. C-50" and if the 50 volt scale were used you would read the value directly as indicated, whereas, if the 100 volt scale were used (and since this is actually read on the 10 volt range) the indication must be multiplied by 10 to get the true reading.

Suppose, when taking a measurement of the filament voltage of a d-c operated set the voltmeter indicates an up-scale deflection with dial #1 set at "A Rev", then the "C" bias measurement should be made with dial #2 at "C-50 A Rev" after first setting dial #1 to position marked "SW. #2" which is done in order to use the 50 volt scale.

It is to be understood that a grid bias reading gives the d-c value of grid voltage at its point of attachment to the filament circuit which is usually the center tap on a resistor connected across the filament in the case of a-c tubes of the filament type. However, for conditions in heater-type tube circuits which use tubes with 5-prong bases the bias reading is the grid voltage measured to the cathode. Then again, for conditions in general in a battery operated receiver the bias reading on the voltmeter is the grid voltage with respect to the positive side of the filament and in this case in order to get the true bias it would be necessary to subtract the filament voltage of the tube from the observed grid voltage. Hence, the use of the "A Rev" provides a reading which is the true voltage to the negative side of the filament.

In receiving sets which use batteries for supplying the "C" bias you should get practically the same grid voltage reading with the tube in or out of the socket because normally there is only a very small flow of current in the grid circuit. However, in the case of a receiver that gets its grid bias from the voltage drop across some resistor the tube must be in its socket so that current will pass through the resistor.

To check the control grid circuit of a screen-grid tube the short lead shown at the upper right in Figure 11 should be connected to the metal cap or tip of the tube and the long lead should be attached to the tube clip in the receiver to complete the control grid circuit to the tester. After these connections are made the dial #1 should be turned to position "SW. #2" and dial #2 to "CONT. GRID - 5" or "CONT. GRID - 100." If the tube under test is being used as a screen-grid amplifier the voltmeter needle will give an up-scale deflection on the "CONT. GRID - 5" setting but if the tube is being used as a space charge amplifier the needle will give an up-scale movement on the "CONT. GRID - 100" setting. When checking the control grid voltage of screen-grid tubes you will find that the voltage under normal conditions is usually very low, or about 1 or 2 volts.

When analyzing from the detector tube socket of a receiver that employs grid-leak detection only a very small value of grid voltage will normally be obtained because the high resistance of the grid leak cuts down this reading. Therefore, if it is desired to get a true grid voltage reading when working with this type of circuit you should temporarily short circuit the grid leak. If a voltage reading were not observed on a tube some of the more common places to investigate for locating the source of trouble would be a poor grid contact in the tube socket, open in a grid bias resistor, open in a grid suppressor resistor, or an open in a transformer winding.

It may be noticed sometimes in checking tubes other than screen-grid tubes that grid current is present in amplifier tubes by the deflection of the needle to the left of zero on the center meter whenever the switches are set for screen-grid current. Assuming that grid current was observed it might be due to a gaseous tube, or perhaps to an oscillating or unbalanced condition in the circuits.

(d) Filament and Heater Circuit Analyses. If the receiver under test is operated from batteries, or any d-c source the filament voltage at each tube socket would be read with the circuit in Figure 11 by setting dial #1 to

"A" or "A Rev" to give an up-scale deflection. The a-c selector switch should be in the "OFF" position at the time and the reading would be observed on the 10 volt scale of the center meter.

In the case of an alternating-current set the a-c filament voltage would be read on the a-c voltmeter by setting the selector switch to the desired range. As a matter of suggestion it would be best to use the 4 volt a-c range when checking 224, 226, 227, or 245 types of tubes and the 8 volt range for 112, 171, 210, or 250 types of tubes.

It is especially important not to have the filament or heater voltages abnormally high or low. If filaments or heaters are operated at a low voltage the emission will be low and this would result in low volume or no output from the receiver and, on the other hand, if excessive voltage is applied the additional current carried by the fine wires in the tubes might cause them to burn out in a short time and the life of the tubes, therefore, would be considerably shortened. While no exact statement can be made regarding this point we might say that no harm will be done, or the operation of the set will not be seriously affected if this voltage is maintained between normal and a value not less than 7% or 8% below normal.

Always keep in mind that tubes of the three-electrode type are completely connected in circuit when they are placed in the set tester socket and the tester plug is in the tube's socket in the receiver. However, tubes of the four-electrode or screen-grid type require the attachment of an extra lead to the cap on the metal tip of the tube and the connection of the lead in the set which ordinarily goes to this metal tip. Thus, it is obvious that no use is made of screen-grid leads when checking three-electrode tubes.

(e) Cathode Circuit Analysis. To obtain a voltage reading of the cathode bias supplied to a tube you would set dial #1 in Figure 11 to the point marked "SWITCH #2" and then set dial #2 to the point marked "K Neg. -50" or "K Pos. -50" according to whichever gives an up-scale deflection and then observe the reading on the 50 volt scale of the center meter.

The cathode voltage employed in a tube is measured with reference to the heater. Hence, in receivers where the cathode is connected directly to the heater the cathode voltage naturally will be zero but on the other hand in receivers where the cathode is grounded through the grid bias resistor with the heater connected to some point in the circuit whose potential is positive the cathode voltage read on the meter will be negative with reference to the heater. There is still another indication that may be found when testing various type of a-c receivers in which the cathode will read positive in reference to the heater and this result is obtained in a circuit where the cathode is grounded through the grid bias resistor with the heater grounded. You should now understand why reverse readings may be obtained where cathode voltages are concerned and that the switch should be placed in the position that will make the needle read forward on the meter scale.

Cathode circuits are seldom the cause of radio troubles but if a cathode voltage reading should be materially different from the value specified for the tube and the tube socket being analyzed it would most likely indicate that the biasing resistor is short-circuited, either partially or completely. Let us add that if you encounter some particular case where

no means are available for obtaining a check on the cathode bias and the bias was incorrect or there was none at all the effect of it would probably result in an excessive hum being heard from the loudspeaker.

(f) Screen-Grid Circuit Analysis. When analyzing screen-grid sockets the readings obtained will indicate the positive potential on the screen grid with reference to the cathode when the tube is of the cathode-heater type, whereas, for filament type tube the reference point is the filament of the tube. Let us repeat that to place a screen-grid tube in operating condition you must connect the short lead on the tester to the metal cap on the tube and the lead in the receiver which ordinarily goes to this cap must be clipped to a terminal on the tester plug provided for this purpose. To take a reading with the circuit in Figure 11 turn dial #1 to "POS. C-100" or "POS. C-50" and read the value on the 50 volt range of the d-c voltmeter directly, or for the 100 volt range it would be read on the 10 volt scale and whatever value was observed would be multiplied by 10 to give the correct reading.

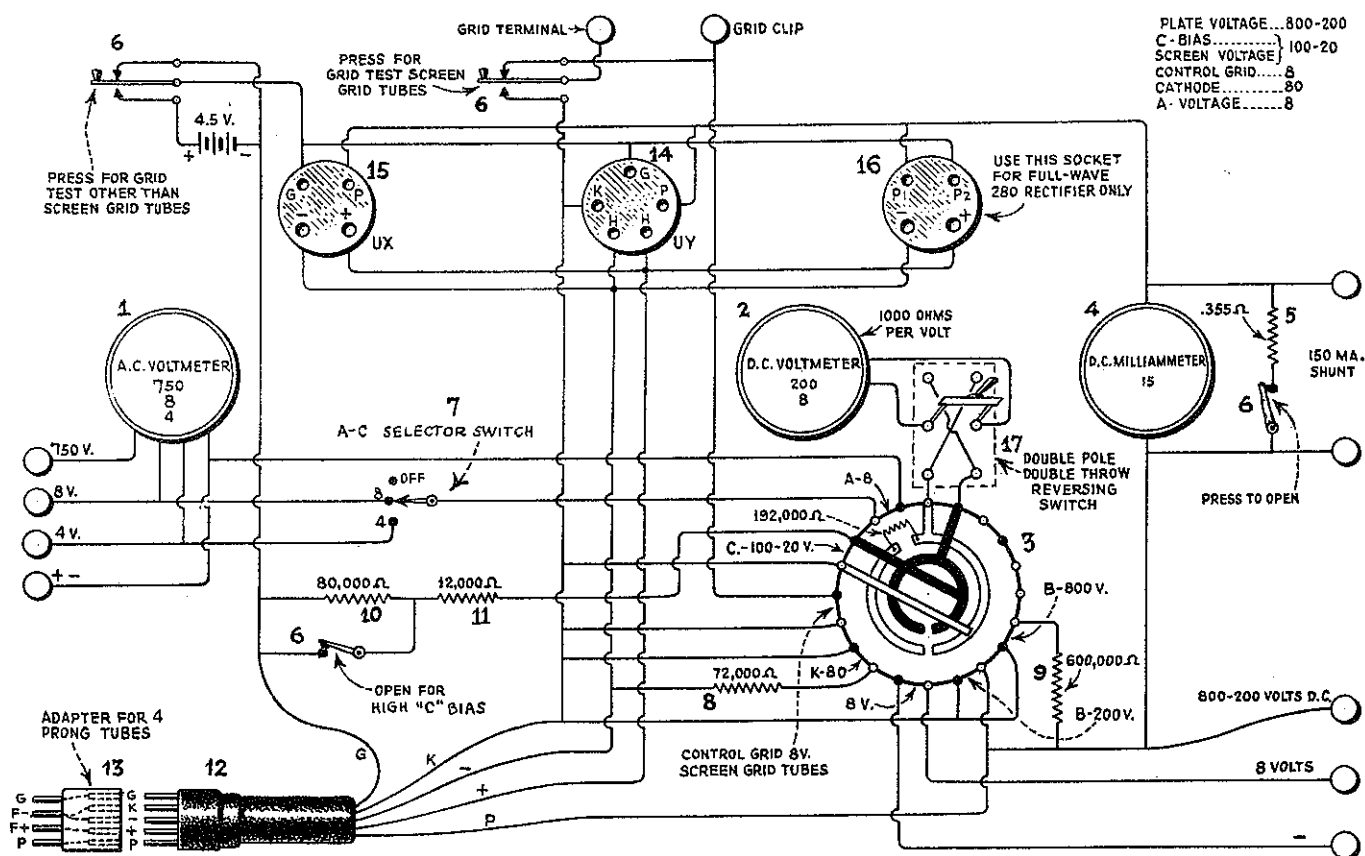
In regard to screen-grid current it can be read by setting dial #1 to "SW. #2" and then turning dial #2 to "SCREEN 2.5 M.A." which connects the 50 scale-range of the center meter to the circuit and, hence, to get the actual reading the needle indication must be divided by 10.

(3) Tube Test. To get a rough check on the condition of a tube a test called a "grid test" is made by simply causing the grid bias to be decreased by 4.5 volts which is the voltage of the small "C" battery contained in the set tester. To make the test you first note the reading on the d-c milliammeter in Figure 11 and then depress the button marked "GRID TEST" to get a second reading and if the tube were in good condition there should be a definite increase in plate current due to the lowering of the negative bias. The amount of increase will vary for different types of tubes and just what change in current should be expected for any tube is determined from a chart especially prepared for this purpose. A chart of this kind is given in one of our lessons on radio servicing. It is to be understood, however, that this does not represent a complete check on the characteristics of a vacuum tube inasmuch as it only shows the control exercised by a change in grid potential over the amount of plate current passing through the tube, but this can be accepted as a fair guide in most cases in telling whether or not a tube is good enough for use. When employing the circuit in Figure 11 a grid test of screen-grid tubes is made by first measuring the control grid bias by setting dial #1 to "SW. #2" and then setting dial #2 to "CONT. GRID -5."

PARTS REQUIRED IN THE ASSEMBLY OF A SET TESTER. A small and compact set tester circuit which would be suitable for making various tests on receiving sets and checking tubes and measuring the voltages and currents in a-c and d-c circuits within the ranges of the meters is shown in Figure 12. For those who would like to assemble such a circuit we have given in the list which follows the diagram a description of most all the necessary parts with the exception of the panel on which the parts would be mounted. To make it easy to identify the parts we have numbered them on the diagram according to the numbers appearing opposite the names of the parts in the list.

From the many photographs and diagrams of typical set testers illustrated in our lesson it should be easy for you to settle on some panel arrangement

All of the parts and instruments of the three-meter set tester shown in Figure 12 may be easily obtained; a description of each item is given in the list appearing at the top of the next page.



Lesson 38 - sheet 29

The parts and the instruments in the set tester described in the diagram in Figure 12 are listed as follows:

No.	1*	1	Weston a-c voltmeter model 476.	0-4-8-150 volts.
"	2	1	" d-c voltmeter model 301.	0-8-200 volts.
"	3	1	" bi-polar switch with resistor for above.	
"	4	1	" d-c milliammeter model 301.	0-15 m.a.
"	5	1	" shunt resistor for above for the 150 m.a. range.	
"	6	4	" push button switches #N.D. 63395.	
"	7	1	" filament selector switch and dial.	
"	8	1	Resistor unit for meter range	72,000 ohms.
"	9	1	" " " " "	600,000 ohms.
"	10	1	" " " " "	80,000 ohms.
"	11	1	" " " " "	12,000 ohms.
"	12	1	Weston five-strand cable and plug.	
"	13	1	" adapter four to five prong.	
"	14	1	Eby UY socket.	
"	15	1	" UX socket.	
"	16	1	" UX socket.	
"	17	1	Double-pole double-throw switch.	
		11	Binding posts.	

* Note that the numbers in the 1st column, from Nos. 1 to 17, identify the parts on the diagram in Figure 12.

A COMPLETE EXPLANATION OF A RADIO TEST PANEL. If any volume of work is to be done in radio servicing and repair it is essential to have a set tester and a tube tester which will meet the requirements of the present-day radio sets. A test panel that could be assembled by any service man and with which numerous tests could be made is illustrated in Figure 13. This is the front view of a test panel whose dimensions are approximately 12½" by 18". It makes a very convenient size for mounting over a work bench. The parts and instruments needed to assemble this panel are obtainable from the Jewell Electrical Instrument Co. If you plan to construct such a panel you will find the actual assembly to be quite simple if you closely examine the various accompanying photographs and wiring diagram. The diagram is given in Figure 14 and a photograph of the rear view with the parts mounted is shown in Figure 15. The view in Figure 16 shows the resistor strip which supports the various multiplier and shunt resistors while the view in Figure 17 illustrates how the panel appears when completely wired. After having finished studying the detailed description of the operation of a typical set tester in this lesson you should readily understand from the markings on the binding posts and parts in Figure 13 what each one is intended to be used for.

An explanation of the features incorporated in this bench type tester panel is contained in the following paragraphs and as you read through you will notice that the discussion centers chiefly around the different meters.

The wiring is so arranged that four of the meters will give simultaneous readings of plate, filament and grid voltages and plate current. Observe that each meter has a complete set of figures printed on its dial to cover every range provided by the meter and, therefore, the needle indications do not have to be multiplied by some number or factor to get the true value, that is all values can be read directly.

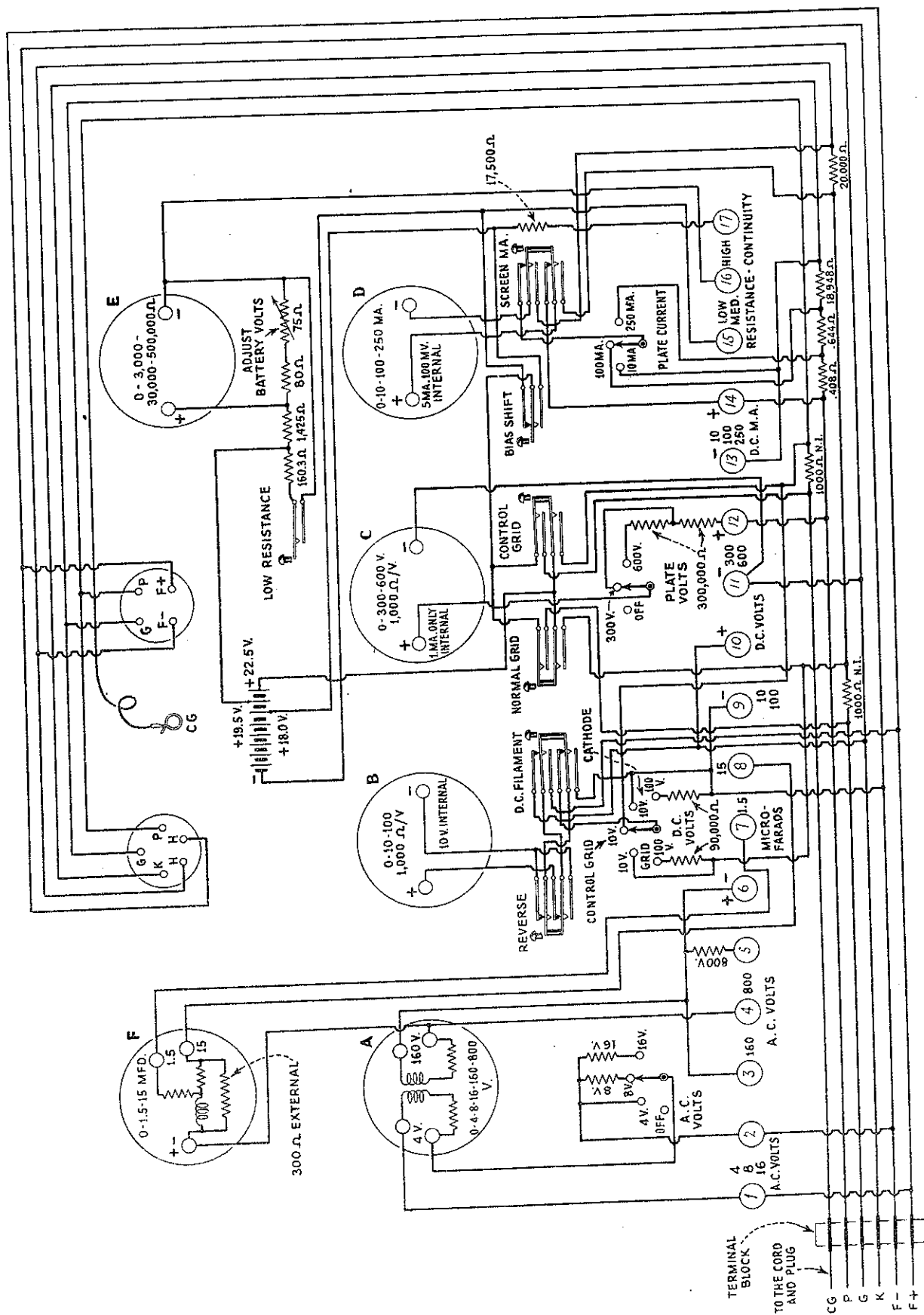


Figure 14

Tubes may be checked by the grid test method. A 22.5 volt battery mounted on the rear of panel as shown in Figure 15 is used for this purpose so that the potential of the grid may be shifted either 4.5 or 22.5 volts, the latter voltage being better suited for power tubes of the '45 or '50 type to provide a definite change in plate current.

When test leads are used in connection with the battery and one of the voltmeters, continuity tests of circuits and parts can be quickly made and open circuits and shorted condensers can be found. In the front view photograph in Figure 13 you can observe the flexible cable with the tester plug attached for making socket-analysis tests of receivers.

How to use a Bench Test Panel. Many of our students may wish to trace through the wiring and switching arrangement of a typical radio service bench test panel. For this purpose we again refer you to Figure 14. The test explained in the following paragraphs would be made with the tube in the socket on the panel and the tester plug in the tube's socket in the radio set.

To check power supply to a radio set you would check the filament voltage of the rectifier tube by turning switch #18 to 8 volts, and the voltage would be read on the 8 volt scale of meter (A). Then to check the plate current passing through the rectifier tube you would turn switch #21 to "250 M.A." and read the current on the 250 milliamperes scale of meter (D). Should the current indicate a value less than 100 milliamperes, change switch #21 and read on the 100 milliamperes scale. The current reading obtained is the total current passing through a half-wave ('81 type) rectifier tube, or one-half the total current passing through a full-wave ('80 type) rectifier tube, that is, the current through only one plate. To check the current through the second plate of a full-wave rectifier tube you would use the 4 hole, 5 prong adapter and take one reading with the rectifier tube in the UX socket (H) and one reading with the adapter in the UY socket (G) of the test panel. Hence, the total plate current is the sum of the two readings.

To check filament voltage of a direct current set operated from batteries turn switch #23 to "D-C FIL" position and the filament voltage available on this tube will be indicated on the 10 volt scale of meter (B). If the meter reads reversed you should turn switch #22 to "REVERSE" position which will cause the meter to read forward. However, if an alternating current set were being tested turn switch #18 to the "4 VOLT" position for the following type of tubes, namely, 224, 226, 227, or 245 and read the filament voltage on the 4 volt scale of meter (A). For the 112, 171, 210, or 250 types of tubes, turn switch #18 to the "8 VOLT" position and read on the 8 volt scale. In other words, turn switch #18 to the proper position, depending, of course, upon the filament or heater voltage of the tube to be tested and read on the corresponding scale of meter (A). With the tube in the test panel, turn switch #23 or switch #18 for proper voltage as just described.

A reading of plate voltage could be had by turning switch #20 to the "600 Volt" position and the 600 volt scale of meter (C) would give the plate voltage of this tube. If the reading were sufficiently low and within the limits of the 300 volt scale then set switch #20 accordingly to the latter scale and thus obtain a close reading on this scale. Plate current of the tube and socket under test is indicated on meter (D) and inasmuch as it is continuously in the circuit, it is best to keep switch #21 on the "250 M.A." position

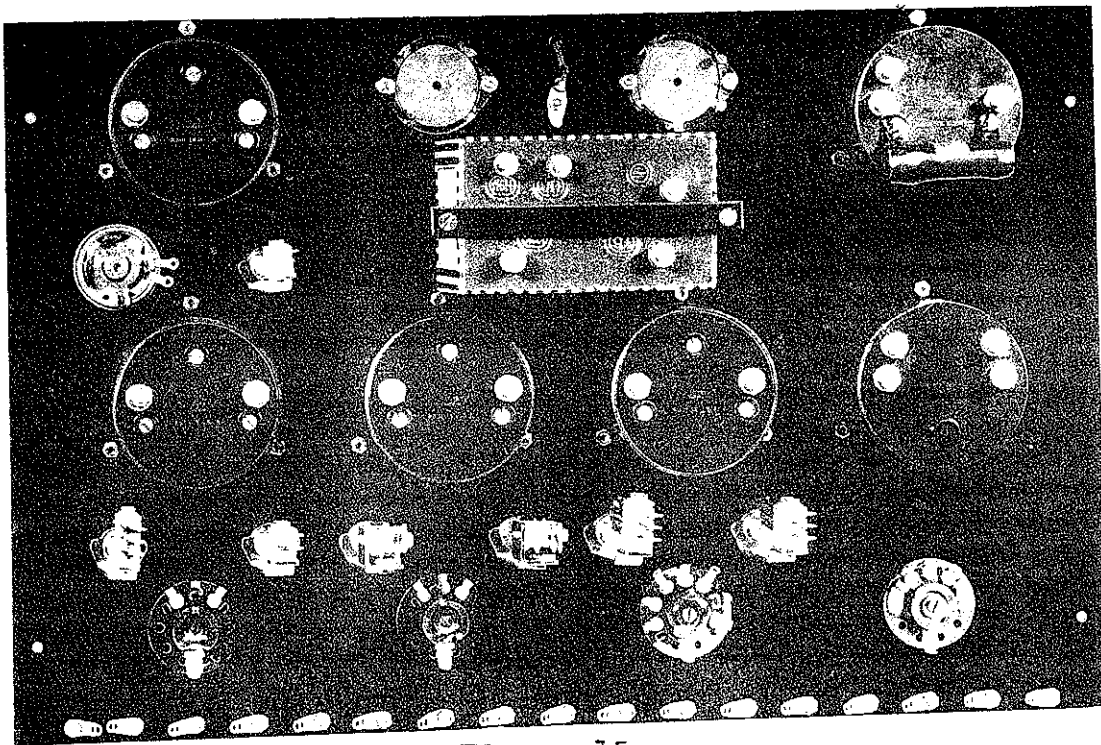


Figure 15

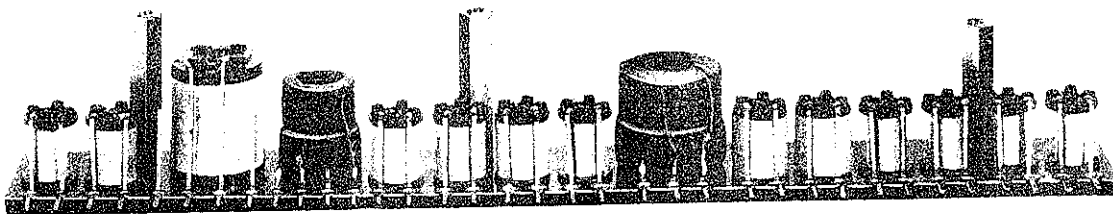


Figure 16

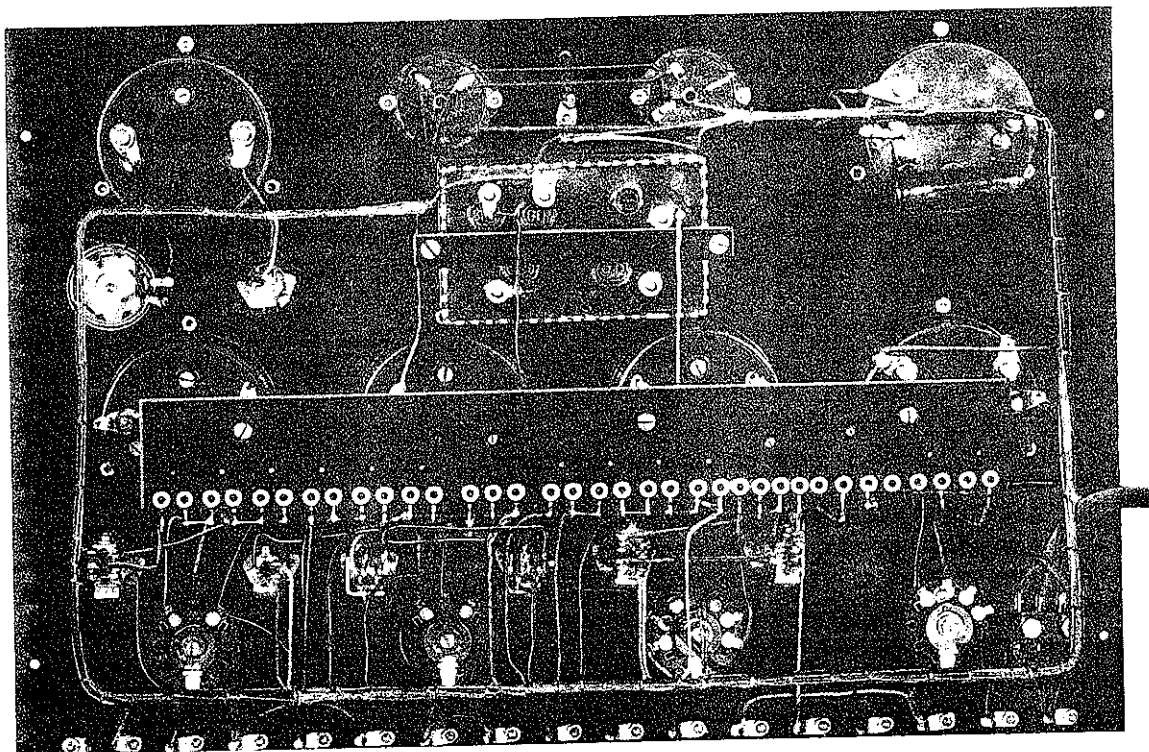


Figure 17

as a matter of protection and then change to the "100 M.A." or "10 M.A." scale as required.

When grid voltage, that is, the control grid voltage of a tube is to be read you would turn switch #23 to "GRID-CATHODE" and switch #19 to "GRID", either to the "10 V" or "100 V" position, as the case may be, and read the voltage on meter (B). For a reading of screen-grid voltage switch #19 would be turned to "GRID 100" position and, also, switch #22 to "REVERSE" and to connect in meter (B). This reading is the positive voltage of the screen with reference to the cathode in the case of heater type tubes, or the filament in the case of filament type tubes.

Now, when a reading of cathode voltage is desired switches #23 and #19 are turned to "CATHODE" position and the value is registered on meter (B). Where cathode voltages are encountered which give a reverse reading, due to the fact that the cathode is positive with respect to the heater, switch #22 should be turned to "REVERSE" in addition which will cause the needle to read forward on its scale.

If, in any of the foregoing tests, you found occasion to test a four-prong tube it would be necessary to use an adapter with the regular tester plug on the end of the cable since this plug has five prongs which is the customary way of arranging the circuits to the plug in standard equipment.

Now we will give the use of every binding post shown on the diagram of the test panel in Figure 14. The first thing to know is that all ranges of each meter are brought to the binding posts to provide readings from separate pieces of apparatus. For instance, the voltage of a "B" eliminator alone may be desired, in which case leads may be run to the high voltage terminals of the meter, proper switches manipulated, and the readings taken. Low voltages, such as those of an "A" battery may be read by turning switch #23 to the "D-C FIL" position and reading voltage on meter marked (B) through binding posts #9 and #10. Hence, when using the binding posts, the test panel plug should not be connected to a radio set and the rule applies to all test equipment of this kind.

Beginning with binding posts #1 and #2 we find that they are used for use in measuring low voltage alternating current circuits. This pair of binding posts connects with the alternating current meter (A), the proper range being circuited through switch #18, so that either the "4V", "8V", or "16V" scale may be selected by merely turning switch #18 to the proper position. For checking line voltages or for other a-c voltages ranging up to 160 volts we would use binding posts #3 and #4, which are marked "160 VOLT A-C". When line voltages are measured a regular cord and plug is used for conveniently making connection to line supply. For measuring high voltage a-c circuits ranging up to 800 volts you would use the test leads supplied with the panel and connecting them to the pair of binding posts marked #4 and #5. This high voltage a-c scale will permit you to check the voltage supplied by a power transformer to the plate or plates of a rectifier tube. In the case of a full-wave rectifier tube the total voltage from plate to plate should be approximately double that which each plate receives, the voltage on each plate being, of course, the voltage across either half of the plate winding, that is, between mid-tap and either extreme end of this winding.

There are three binding posts, #6, #7, and #8 which are used for capacity measurements as follows: The source of the voltage for obtaining the measurements is provided through the cord and plug inserted in the lamp socket or wall outlet of the a-c power system. First, connect the cord tips of the cord and plug assembly to binding posts #3 and #4 and place the plug in the lamp socket and meter (A) will indicate the a-c line voltage on its 160 volt scale. A condenser capacity is measured by connecting the terminals of the condenser under test directly across binding posts #6 and #7, or across posts #6 and #8 by means of the flexible test leads. When making condenser tests be sure the proper posts are used, depending on whether or not the condenser capacity value is greater than 1.5 microfarads or within the 15 microfarad range. Since the capacity indicated is proportional to the line frequency and the scale calibration of the meter is for 60 cycles then if used on a 50 cycle line, the actual capacity of the condenser would be 1.17 times that indicated, and on 25 cycles, 2.4 times that indicated. Also, since the calibration of the capacity meter is for an a-c voltage of 115 volts, then should readings be made with a line voltage varying from this value, the resulting readings will be correspondingly high or low. If a condenser is short-circuited the a-c current in passing right through the condenser from plate to plate would cause the pointer to swing to the right end of the scale or to the point marked "SHORT". In the case of an open circuit there would be no proper connection to the condenser's plates and, consequently, the pointer would not move at all; it would remain at the "OPEN" position on the scale.

The next pair of binding posts, #9 and #10, are used in reading low values of d-c voltages on meter (B), the range desired being selected by setting switch #19 to "CATHODE 10" or "CATHODE 100". When high d-c voltage values are to be measured, binding posts #11 and #12 are used to connect meter (C) to the circuit and the desired range is selected by means of switch #20.

Where a check up of the current in a d-c circuit is desired binding posts #13 and #14 are used, the reading being taken on meter (D) and the range being selected by means of switch #21. In addition switch #27 must be in the "PLATE CURRENT" position.

No doubt, the most frequently used binding posts on any test panel are those which are used for making continuity and resistance measurements. On the diagram in Figure 14 these posts are #15, #16, and #17. To place this circuit in readiness for such tests you would attach respective ends of the test leads to the proper pair of binding posts and the opposite ends of the leads, on which would be found the test prods or points, would be placed across the portion of the circuit to be tested. Voltage for these measurements is supplied from a 22.5 volt tapped battery mounted on the rear of the panel, so that for low and medium ranges you could use 1.5 volts, and for higher ranges 19.5 volts. The rheostat shown on the panel permits you to adjust all ranges to the existing battery voltage and to make this adjustment you need only to short-circuit that range at the binding posts and adjust the rheostat until the pointer of meter (E) indicates zero resistance at the right-hand end of its scale.

Whenever the continuity test is used to check circuits or parts for "opens" then you should connect one of the test leads or points to one end of the circuit being tested, and touch the other test point momentarily to various points along this circuit, starting where the first mentioned test lead is connected. Thus by this means you can easily find a break or open, because

when the faulty place in the circuit is reached there will be no indication on the meter, that is, no movement of the needle will be observed. Of course, you must remember that when testing a perfect condenser alone it will show an open circuit on a continuity test. Hence, you should exercise care in such tests and not become confused when a condenser is involved. For instance, a condenser in a receiver might show a short circuit test but in reality you may be testing through some resistor or transformer or choke winding which may be shunted around the condenser in question. So, we advise you to be careful when making such tests. To be absolutely sure that any condenser which is shunted by a wire circuit or a metallic circuit is in good condition the condenser should be disconnected from its circuit during the test.

How to use the test circuit in Figure 14 for measuring low, medium, and high resistances: A measurement of low resistance would be obtained by connecting the test leads to binding posts #15 and #16, and placing switch #28 in the "MED. RES." position, and the reading observed on the 30,000 ohm scale of meter (E) would be divided by 10 to get the true value. For medium resistance measurements, binding posts #15 and #16 could be used with switch #28 in the "MED. RES." position, and hence the true value in this case would be had by dividing the reading taken on the 30,000 ohm scale of meter (E) by 10. For high resistance measurements the circuit or unit under test is connected to binding posts #16 and #17, and the resistance value is read directly on the 500,000 ohm scale of meter (E). To cite one example of a correct resistance indication for a given test we will explain what effects you would expect to obtain on your meter when testing a lightning arrester. This device should be checked for a very low resistance circuit between the antenna terminal and the set terminal, and a very high resistance or open circuit between the antenna and set terminals and the ground terminal. Where a certain type of lightning arrester is supplied with one common terminal for the antenna and set connections the arrester should check open circuit or a very high resistance between this terminal and the ground terminal.

The panel in Figure 14 also provides a tube test by changing the grid bias a definite amount, the amount of the change of grid bias being controlled by switch #26. This switch should be placed in the left hand or "4.5 V" position when testing amplifier tubes. However, for power tubes, such as types '45 and '50, switch #26 should be turned to the right hand or "22.5 V" position in order to get a larger grid change for such tubes operating with greater power. In the case of any three-electrode tube the grid change is obtained by operating switch #24 from the "NORMAL" to the "SHIFT" position, but for four-electrode or screen-grid tubes the shift is obtained by operating switch #25 from the "NORMAL" to the "SHIFT" position. As we have stated before in our lesson this definite change in grid voltage should change the value of the plate current a definite amount for a normal tube.

To summarize this lesson we learn that the purpose of set testing equipment is to provide a means for quickly and accurately checking all tubes, testing the primary and secondary windings of power transformers, measuring the voltages at the source of the power supply and taking it all-in-all, subjecting the various circuits of a receiving set to a critical analysis. Any readings obtained during the tests that are found to be at considerable variance from normal readings usually lead the serviceman to the location of the trouble. In other lessons on this subject of radio servicing we

have taken up detailed discussions on the continuity set tester, ohmmeter, tube tester, grid-dip meter, output meter and so on and, also, there are numerous points included on the possible causes of faulty operation in receiving sets powered from alternating-current lines.

EXAMINATION - LESSON 38

1. Give a brief outline for systematically testing a receiving set which you were called upon to service, assuming you had no previous instruction about the condition of the set or the possible cause of the difficulty.
2. (a) How may the range of a voltmeter be extended? (b) What is the principle governing this method?
3. (a) How may the range of an ammeter be extended? (b) Explain the principle.
4. What is meant by a socket-analysis test and of what advantage is it in servicing a receiver?
5. Name each of the principal circuit analyses that may be taken with the average type set tester and tell what you can about each analysis.
6. In the diagram in Figure 11 what is the 4.5 volt battery used for?
7. Before attempting to service a receiver and turning power on the set what precautions would you take?
8. Mention one or more circuits in certain types of receivers that cannot be reached by socket-analysis testing. How are they tested?
9. To indicate correct working conditions is it necessary to have the electrical values obtained at the various sockets and other points in a receiver always compare exactly with the values given on the manufacturer's chart for that set? Give the reasons for your answer.
10. (a) Would you run a series of tests on an a-c set with a set tester if each socket of the receiver other than the socket which held the plug, was not supplied with a tube? Why?
(b) When making socket-analysis tests of different types of receivers why is it you may get reversed readings of cathode voltage?